PROJECT DESIGN AND CONSTRUCTION

LOCATION AND ROUTING

PRUDHOE BAY LATERAL PIPELINE

GENERAL RECOMMENDATION

In order to protect the unique environment of the northern Yukon Territory and the Mackenzie Delta, as well as the way of life of native people in this region, the Prudhoe Bay gas pipeline should not cross the Northern Yukon along either the Coastal or the Interior route, but rather should follow a more southerly route or corridor.

If a permit is granted for a trunk pipeline from Prudhoe Bay along the Coastal or Interior route, the Government of Canada should adopt policies of affording maximum protection to wildlife and fish in the vicinity of the pipeline and of preserving in its natural state as much of the nearby land as possible. These policies should be applied to nearby governmental and industrial activities as well as to the pipeline project. Moreover, the government should ensure that the location, construction and operation of the project are adjusted to conform to these policies and to meet the concerns of the local people, particularly those of Old Crow, as outlined in the following.

DISCUSSION

The Arctic Gas Application is for the Coastal route but if the Coastal route is not acceptable to government then the Application applies to the Interior route. Thus, a rejection of the Coastal route by Canada or the U.S.A. would be needed for the Interior route to be considered for a permit. However, both routes have required close scrutiny by the Inquiry to determine the implications for Canada of accepting or rejecting the Coastal route. Modifications of the Arctic Gas Coastal route to follow a route across the Mackenzie Delta instead of following the original Circum-Delta route has further complicated the process of decision.

The Fort Yukon and Fairbanks corridors identified by Arctic Gas as possible alternatives to the northern Yukon routes for a Prudhoe Bay gas pipeline are not part of the Arctic Gas application and, therefore, have only been reviewed in broad terms by the Inquiry. Moreover, the recent proposal by Foothills (Yukon) Ltd. to build a gas pipeline from Prudhoe Bay through the Fairbanks corridor has not come under the scrutiny of the Inquiry. Thus only the most general comment is made here regarding a southern Yukon alternative.

Much evidence has been brought before the Inquiry concerning potential impacts of a gas pipeline and of development that could follow a gas pipeline along the Coastal route and the Interior route. Strong objections have been offered by native people relative to a gas pipeline along either route and particularly regarding the Interior route pipeline and its effect on Old Crow. Moreover, most of the really important concerns over mammals, birds, fish and the protection of the environment in general that have been brought before the Inquiry apply to the various options for the Prudhoe Bay lateral. All of the routing options involve major environmental concerns. In particular the Coastal Cross-Delta route which is the present prime route of Arctic Gas is the focus of many critical concerns over environmental impact.

Comparison of the Coastal, Interior, Cross-Delta and Circum-Delta options for the Prudhoe Bay lateral in Canada from various points of view has produced no clearly defined basis for preference of the Interior route or the Coastal route. It has proved difficult to separate concerns over the gas pipeline as it is proposed, from what various people consider might go wrong with the project during construction, and from concerns over other developments

that might follow the gas pipeline along any chosen route. Bearing all these in mind, the following generalizations have been drawn from the information at hand.

1. Environmental concerns for the Cross-Delta route are substantially higher than those for the Circum-Delta route. In socio-economic terms it has been argued that the Cross-Delta route is of lesser concern than the Circum-Delta route, but no clear evidence of difference has been presented.

2. Native people have expressed substantially greater concern regarding the Interior route than for the Coastal Cross-Delta route. Socio-economic comparison of the Interior route and Coastal Circum-Delta route is less clear although the Interior route probably is of greater concern. In contrast environmental concerns for the Interior route (in Canada) are substantially lower than those for the Coastal Cross-Delta route and are also lower than those for the Coastal Circum-Delta route.

A nagging uncertainty in making the above comparisons and in drawing up recommendations on routing of the Prudhoe Bay gas pipeline arises from the possibility that industrial "corridor" development along the Coastal route may ultimately be inevitable in view of the potential for petroleum discovery on the coastal plain or adjacent continental shelf. However, it is noteworthy that this area has not been granted prominence in present exploration strategies.

RECOMMENDATIONS

General Routing

1. In the context of the regional socio-economic and environmental considerations that constitute the focus of this Inquiry, it is recommended that the Prudhoe Bay gas pipeline should not cross the Northern Yukon, but rather should follow a more southerly route or corridor. In this connection the Northern Yukon includes both the Arctic Gas Coastal route (via the Cross-Delta or Circum-Delta options) and the Arctic Gas Interior route. This recommendation stems from the major difficulties that would be involved in protecting the environment and the people of Old Crow from the impact of development, and applies to the gas pipeline project, per se and also to development of an energy transportation corridor that could follow the route of the pipeline.

2. Based on the limited review by this Inquiry of alternative pipeline corridors for a pipeline across the Yukon Territory as put forward by Arctic Gas, the "Fairbanks Corridor" along the Alaska Highway offers environmental advantages over the routes across the Northern Yukon.

Coastal Route

3. If a permit were to be granted for a trunk gas pipeline from Alaska along the Yukon Coastal Plain, the Government of Canada concurrently should adopt a policy of preserving in its natural state as much as possible of this unique area and of providing maximum protection to wildlife and fish. The following measures are recommended for implementation under this policy. The Company shall:

   a) submit to the Agency, for approval and direction at preliminary design, a rationalization and optimization of its route and facilities locations in terms of potential impact on birds, mammals, fish and traditional land use by native people, including environmental, engineering and cost comparison of alternative right-of-way, borrow and facilities locations. This analysis is to include, as one possibility, a route through the already disturbed areas at and around DEW line sites (136:20605-26);

b) strictly adhere to the winter construction and snow road logistic mode (i.e. no permanent road or gravel work pad along the right-of-way);

c) reduce summer-time activities, during construction and operation, to an absolute minimum, and allow flexibility in timing of any necessary summer activities;

d) apply conservative design and construction practices along the full length of the coastal plain so as to minimize the need for repairs and particularly contingency repairs;

e) follow a surveillance and maintenance program during pipeline operation that is specifically designed to avoid impact on mammals and birds; and

f) meet the concerns for protection of birds, mammals and fish outlined for this area in "Protection of Wildlife" and "Protection of Fish". Special attention should be given to control of aircraft and particularly helicopters, protection of the Porcupine caribou herd in the calving and post-calving period, protection of staging snow geese in autumn, and protection of overwintering fish in rivers.

The Government should:

a) place restraints on ongoing industrial and government activities and ongoing use of aircraft throughout the coastal plain and adjoining nearshore zone comparable to the restraints placed on the pipeline project. These restraints should apply through the construction period and be re-evaluated thereafter;

b) set aside as provisional land reserves, the Yukon Coastal Plain and, in more general terms, the whole of the northern Yukon between the coast and the Porcupine River (ie. the area of the proposed International Wildlife Range) in accordance with the recommendations contained in "Land Reserves";

c) under this reserve and pending formal disposition of the reserved area, prevent or curtail new industrial activities; and

d) prohibit entry on to the Yukon Coastal Plain for hunting or fishing except by native people engaged in traditional land uses. These restraints should apply through the construction period and be re-evaluated thereafter.

Cross-Delta Route

4. If a permit were to be granted for a trunk gas pipeline from Alaska across the Mackenzie Delta, the Government of Canada should indicate in unequivocal terms that approval of the gas pipeline does not constitute approval of an energy transportation corridor across the delta and is not to be taken as a precedent for routing a trunk oil pipeline across the delta. In addition, the government should ensure, as a matter of policy, that the pipeline company will achieve high standards of protection of wildlife, fish, land and water. The measures outlined below are further recommended in this regard. The Company shall:

   a) submit to the Agency, for approval and direction at preliminary design, a rationalization and optimization of its route and facilities locations on the delta in terms of potential impact on birds, mammals, fish and traditional land use activities by native people, including environmental, engineering, and cost comparison of alternative right-of-way and facilities locations; this analysis is to include the "Barry Route" as well as other options (122:18584-87, 18725-26);

   b) unless the "Barry Route" is adopted, build the crossing of Shallow Bay in winter to avoid the effect of summer construction on whales, staging snow geese and other waterfowl;

   c) strictly adhere to winter construction with snow road logistics for all segments of the pipeline on the modern Mackenzie Delta with the exception of crossings (i.e. no summer construction or gravel work pad along the right-of-way);

   d) reduce summer-time activities during construction and operation to a minimum and allow flexibility in the schedule of any summer activities that are necessary;

e) apply conservative design and construction practices to the pipeline within the Mackenzie Delta to minimize contingencies and the need for repairs, use dual pipe in all areas potentially subject to flooding, provide for continuous weighting of the pipe, and install cross-overs between the two pipes;

f) limit the quantity of fuel stored at any one place and time within the delta, as outlined in "Spill Prevention and Control";

g) follow a surveillance and maintenance program during pipeline operation that is specifically designed to avoid impact on mammals and birds, including limitations on use of aircraft, hovercraft, and boats during summer (<u>see</u> "Project Operation");

h) meet the concerns for protection of birds, mammals, and fish outlined for the Mackenzie Delta in "Protection of Wildlife" and "Protection of Fish"; special attention should be given to control of aircraft and particularly helicopters, handling of fuel, protection of white whales, and protection of staging snow geese; and

i) avoid contact and conflict with hunting, trapping, and fishing activity by native people.

The Government should:

a) withdraw as provisional land reserves, the whale sanctuary and waterfowl reserve areas recommended in "Land Reserves";

b) pending formal disposition of these reserved areas, apply restraints to or relocate existing industrial and governmental activities, including use of aircraft and barges, within these reserved areas comparable to the measures specified in this report for protection of whales and waterfowl. Also, pending formal disposition of these reserved areas, the government should curtail or prevent new industrial activities that could place at risk the whales and birds that the reserves are designed to protect;

c) within a zone extending 5 miles on either side of the pipeline route across the delta, place restraints on

industrial and governmental activities (including use of aircraft) comparable to the restraints placed on the pipeline project: this condition should apply through the period of pipeline construction and should be re-evaluated thereafter;

d) establish a general policy of regulating industrial development in the delta so as to afford maximum protection to wildlife and fish, and to preserve as much of the delta as possible in its natural state.

Circum-Delta Route

5. If a permit were to be granted for a trunk gas pipeline from Alaska around the west side of Mackenzie Delta via the Arctic Gas prime route of March 1974 (Circum-Delta route) the location of the pipeline, pipeline facilities and all other related land use should be adjusted to avoid encroaching upon all areas of special importance to the native people of Aklavik, Fort McPherson and Arctic Red. Adjustments should also be made to avoid interference with fishing, trapping and hunting by the local people and to meet the environmental concerns about this route that are identified elsewhere in this submission.

6. At preliminary design, the company should submit to the agency proposals (with alternatives) for adjustments in route and in location of facilities etc. (and/or adjustments in procedures and schedules) to achieve the above. Particular reference should be made to:

   a) avoiding interference with domestic fishing in Mackenzie Delta channels (e.g. "Big Eddy"), Rat River, Peel River, and Mackenzie River near Arctic Red;

   b) avoiding disturbance of fish in localities critical to fish populations including Willow River, Rat River and Big Fish River;

   c) moving the compressor station and associated facilities away from Rat River;

   d) minimizing disturbance of the Mount Goodenough Dall sheep population; and

e) minimizing disturbance of lands and waterbodies within the Mackenzie Delta and similar terrain along Peel River (work pads, wharves, storage areas, roads, right-of-way), including limitation of the amount of fuel stored in areas subject to flooding.

Interior Route

7. In the context of the regional socio-economic and environmental considerations that constitute the focus of this Inquiry, it is recommended that the Prudhoe Bay gas pipeline should not follow the "Interior route" proposed by Arctic Gas or pass through this region. This recommendation is directed principally to that part of the Interior route between the Alaska border and the Peel River and reflects both the overwhelming opposition of the Old Crow people and the substantial environmental concerns about this pipeline, particularly concerning the Porcupine caribou herd. This recommendation applies to the gas pipeline per se and to the concept of an energy transportation corrider following the route of the pipeline.

8. Should the Government of Canada seriously consider granting a right-of-way for a trunk gas pipeline through the region traversed by the Interior route proposed by Arctic Gas, then it is recommended that a route diversion well south of Old Crow (Templeton, 108:16529) should be reviewed in terms of its acceptability to the people of Old Crow (as well as its technical feasibility and acceptability to the Company) prior to reaching any final decision.

9. If a permit were to be granted for a trunk gas pipeline from Alaska across the northern interior of the Yukon Territory (assuming an agreement were to be reached with the Old Crow people), the Government should:

   a) ensure that the pipeline logistic system and pipeline-related traffic of all kinds avoid, in a manner acceptable to the local people, Old Crow and the areas traditionally used by Old Crow residents for the harvest of renewable resources

b) ensure that the pipeline is built in winter using snow road logistics and that permanent gravel roads are kept to an absolute minimum, as a means of further limiting access to the region;

c) prohibit hunting and fishing within 5 miles of the pipeline, its access routes, and pipeline facilities, with the exception of traditional land use by native people. This restraint should be applied through the construction period and be re-evaluated thereafter; also similar no hunting zones should be enforced along the Dempster Highway and other roads or winter trails as deemed necessary to protect the Porcupine caribou herd during pipeline construction (see "Game Management and Monitoring");

d) place restraints on aircraft flights and any other industrial or governmental activities within 5 miles of the pipeline route comparable to the restraints applicable to the pipeline project. These restraints should be applied throughout the pipeline construction period and be re-evaluated thereafter;

e) set aside as a provisional land reserve, the area north of the Porcupine River within the boundaries of the proposed International Wildlife Range in accordance with the recommendations contained in "Land Reserves"; and

f) ensure that both the construction and the operation of the pipeline meet the concerns for protection of birds, mammals and fish outlined for this area in "Protection of Wildlife" and "Protection of Fish".

SOURCES OF INFORMATION

1. Transcripts, Exhibits, Basic Documents

CAGPL	Banfield, F.; Dabbs, D.L.; Gunn, W.H.; Hemstock, R.A.; Jakimchuk, R.D. (136:20605-26)
COPE	Barry, T.W. (122:18584-87, 18725-26)
EPB	Templeton, C.H. (108:16529)

MACKENZIE VALLEY PIPELINE ROUTE

GENERAL RECOMMENDATION

The route of the gas pipeline along the Mackenzie Valley and the location of all lands used for the pipeline should be adjusted to meet environmental concerns, to stay away from the small native communities along the valley and to avoid all other areas of special concern to the native people.

If a gas pipeline from Alaska were to be built across the southern Yukon, then a pipeline routing southward from the Mackenzie Delta along the Dempster Highway could have advantages over the Mackenzie Valley pipeline, both for the environment and for native people. The appraisal of this route is therefore recommended.

DISCUSSION

Throughout the very considerable discussion before the Inquiry concerning location of the Mackenzie Valley pipeline between Taglu and Latitude 60°N, the overall broad routing along the Mackenzie Valley has generally been taken for granted in terms of engineering, transportation, governmental, local business and environmental considerations. On the other hand, a Mackenzie Valley routing is at present unacceptable to a large number of native people, although the native people have insisted on their right to reserve decision on routing questions pending settlement of their land claims.

Although Roed, (77:1446-88; 78:11489-596) on behalf of CARC, has proposed two alternative routes east of the Mackenzie Valley neither has seemed to spur any substantial interest at the Inquiry. Thus his "Edge of the Shield" route does not appear to hold serious possibilities for the presently proposed gas pipeline and although his "East of the Franklins" route has some environmental advantages over the Mackenzie Valley corridor, its disadvantages may outweigh the advantages in both environmental and socio-economic terms. Moreover, there has been little discussion of the possibility of routing the pipeline along the west side of Mackenzie Valley even though one of the early gas pipeline proposals (Northwest Pipeline Study Group) followed such a route. The Dempster Highway routing for a pipeline to carry gas southward from Mackenzie Delta was given only brief attention at the Inquiry (Hughes 54:7612-24, Geist 54:7431-33) in the

context of a "spur" line to connect to the southern Yukon corridors (Fairbanks corridor and Fort Yukon corridor). Despite the very limited information at hand regarding potential impact of a pipeline along this route, its location along an already developed transportation route is an indication that it may have advantages, both environmentally and perhaps for native people.

On a more local scale, various changes in routing and location have been introduced by both Applicants and many additional changes have been recommended by witnesses brought forward by other participants as well as by individuals at the community hearings. The Fort Simpson route change, by which Arctic Gas introduced its present routing east of Fort Simpson, is a substantial improvement in environmental terms. Concern over the routing through the Ebbutt Hills IBP site (Mirosh, 60:8580, Hemstock 52:6953) is minor, although the compressor station and wharf site location across the Mackenzie River from Fort Simpson is of some concern (Dau, 18:2117). The second major change, by Arctic Gas in which the "prime" route south from Taglu to Travaillant Junction to Thunder River was abandoned in favour of the Cross-Delta option running directly from Taglu to Thunder River, involves no substantial overall change in potential pipeline impact either environmentally or in socio-economic terms. Despite local differences in location between the present "mainline" proposals of Arctic Gas and Foothills the two routes are generally similar in overall potential for environmental or socio-economic impact.

Changes on a more local scale include the following: both companies have made changes in river crossing locations, in wharf and stockpile sites, and routing of access roads; both have introduced the Niglintgak lateral pipeline; Arctic Gas changed the routing of its Parsons Lake lateral pipeline; Foothills has made minor adjustments in pipeline routing north and south of Norman Wells; and Arctic Gas has abandoned many communication towers and associated access routes. Most of these changes involve some degree of improvement in socio-economic or environmental terms but it is obvious that much more improvement can be achieved by further adjustment of the routes and the location of facilities and other pipeline land use.

Basic concerns about the location of the pipeline in the Mackenzie Valley and of associated facilities have been presented to the Inquiry by native people in all the communities along or

near the proposed route. These concerns although rarely focussed, specifically encompassed the location of pipeline lands in relation to the communities themselves, traditional land use areas, sites of religious importance, and geographic features of special significance to native people such as the Great Bear River. Both pipeline Applicants have responded to some of these concerns with changes in location or offers of changes. For instance, Arctic Gas (Exhibit 493) has relocated wharves, stockpile sites, access roads, and airfields to keep away from Fort Good Hope, Fort Norman and Wrigley. To date, such changes appear to have been introduced unilaterally and there appears to have been no progress towards a review process for resolving differing positions regarding pipeline routing and location. In fact, there has been little effective communication between local people, the Company, government, and environmentalists in this regard. Nonetheless, the "1972 Pipeline Guidelines" states on page 29: "Where the pipeline construction is planned to be located in proximity to a settlement -- particularly a native settlement localized area subject to intensive use, then the location of construction camps, associated activities and the detailed siting of the pipeline will be decided by government after consultation with the Applicant, and the settlement council, or local government body, or the native organization".

RECOMMENDATIONS

1. If a gas pipeline from Prudhoe Bay across the southern Yukon is under serious consideration, then the Dempster Highway route should be assessed and reviewed, on a priority basis, as an alternative to the Mackenzie Valley route for transport of gas (and as an energy transportation corridor) southward from the Mackenzie Delta. As noted in the foregoing, a gas pipeline along the Dempster Highway could have advantages over a pipeline through the Mackenzie Valley both environmentally and perhaps for native people (although the Inquiry has heard only general information about this route).

2. Apart from the Dempster Highway system cited above, there is no obvious and environmentally advantageous alternative to the Mackenzie Valley for routing of a gas pipeline and an energy transportation corridor southward from Mackenzie Delta.

3. Routing of the Mackenzie Valley pipeline and the location of all lands to be used by the pipeline project should be adjusted to stay away from the small Dene communities along the valley, and to avoid encroaching upon all other areas of special importance to the native people. Review of the options available to meet this need, by government, local people and the Company, should include the possibility of locating the pipeline west of Mackenzie River.

4. The routing of the Mackenzie Valley pipeline and location of all lands proposed for use by the pipeline should be adjusted to reduce potential environmental impact. In this regard, at preliminary design, the Company shall submit to the Agency for review and approval its proposals for modifying the route and locations to meet environmental concerns. Where deemed appropriate by the Agency, these proposals will include comparison of alternative locations in terms of engineering and cost as well as environmental and social factors. In particular Company proposals should deal with the following matters:

   a) Adjustment of the location of compressor stations and of the groups of facilities associated with the compressor stations so as to stay away from valleys and rivers tributary to the Mackenzie and the mouths of tributaries (see "Location of Facilities"). If a compressor station cannot be moved, then the associated facilities (wharf, stockpile site, airfield, borrow pits, road, camp, sewage plant, and wastedump) shall be kept away from the tributary valleys, tributary rivers and their mouths.

   b) Adjustment of the location of wharves and stockpiles along the Mackenzie River to avoid interference with fishing sites.

   c) Modification of the location of the Swimming Point crossing of the East Channel and avoidance of the nearby pipe and road crossings of Holmes Creek (Foothills) to reduce potential impact on the Holmes Creek fishery.

   d) Adjust the location of various stream crossings to avoid areas of fish sensitivity. Some locations of this kind are recorded in "Site-Specific Recommendations: Fish".

e) Modification of location of borrow pits to avoid potential borrow resource conflicts (<u>see</u> "Borrow Resources").

f) Adjustment of route and locations and established aircraft flight corridors to meet the concerns outlined in "Wildlife Protection".

g) Avoid areas designated as important for recreation (<u>see</u> "Recreation Areas").

h) Relocation of the pipeline, access routes and roads, facilities and borrow pits insofar as possible on already disturbed ground.

i) Adjustment of the pipeline route to minimize the length of pipeline on terrain that is potentially troublesome in terms of frost heave, thaw settlement, slope stability, buoyance and erosion.

j) Review on a mile by mile basis of location of the pipeline and associated facilities in relation to the Mackenzie Highway route in terms of potential separate and cumulative environmental impact and propose pipeline and/or highway relocations designed to minimize such impact.

k) Adjustment of the pipeline route and locations to avoid conflict with areas proposed or set aside as provisional land reserves (<u>see</u> "Land Reserves").

SOURCES OF INFORMATION

1. <u>Transcripts, Exhibits, Basic Documents</u>

CAGPL	Dau, P. H. (18:2117); Hemsotck, R.A. (52:6953)
FH	Mirosh, E.A. (60:8580)
CARC	Geist, V. (54:7431-33); Hughes, O.L. (54:7612-24); Roed, M.A. (77:11446-88; 78:11489-596)
Exhibit	493: Letter 8 March 1976 from J. Marshall to Ian Scott re: CAGPL plan refinements and Maps.

SCHEDULING AND LOGISTICS

GENERAL RECOMMENDATIONS

The Company and all its contractors shall schedule its work and logistics support activities in a manner which will:

(a) comply with all federal and territorial legislation, regulations, ordinances concerning safety and security, land use and protection, wildlife protection and all stipulations of the Agency; and

(b) be cognizant of the needs and desires of the northern communities near or through which the pipeline shall pass.

The Company shall develop an analytical model of the whole pipeline construction process, showing in detail the construction schedule for every part of the entire construction process, such model to be submitted for government inspection prior to final design. The model shall have sufficient flexibility to accommodate all foreseeable delays, including, but not limited to, location or design changes, major equipment failures, major hold-ups in material supply, labour problems, unexpected wildlife, fish or human activities. A contingency plan is to be included for each likely hold-up factor and possible combination of factors.

DISCUSSION

Major construction projects which involve large numbers of men and the supply of large amounts of material, working to a tight schedule, can run into considerable difficulty in keeping to schedule, even under normal construction conditions. The Mackenzie Valley pipeline is to be built through a region with unique technical, environmental and social conditions. Considerable concern has been expressed at the Inquiry that construction will fall behind schedule. The performance of the Alyeska Pipeline Service Company in Alaska has shown that the efficiency of winter construction has been very low. In addition to hold-ups arising from bad weather, that pipeline project also faced major wintertime losses of labour.

Both Applicants plan the major portion of their construction for winter. Both construction plans depend heavily on the use of snow roads. Arctic Gas plans to start construction in November through making extensive use of snow-making equipment (if necessary) in preparing these roads. Foothills, asserting that it is not possible or safe to use artificial lighting to the

extent planned by Arctic Gas, does not plan to commence actual pipe laying until January.

Foothills has charged that Arctic Gas has entirely overestimated spread productivity, that the number of unproductive days will in fact be far higher than estimated by Arctic Gas, and that it will not be possible for Arctic Gas to commence construction as early as November. It is claimed by Foothills that labour will not work through the Christmas season, and that labour will not stand for the uncomfortable and unsafe working conditions to be imposed through having to work under artificial lighting during the long, cold winter.

For its part, Arctic Gas has stated that it has obtained all its information for preparation of its plans from informed and experienced sources, and that its productivity figures are based on standard Canadian pipelining procedures. Although discussion had not been held with the actual unions to be involved at the time of Arctic Gas' first presentation of its construction plans to the Inquiry, consultations with the contractors chosen to give estimates on the line revealed that winter construction on Canadian pipeline jobs is in fact standard. Labour agreements within the industry meet most of the likely objections from workers. Furthermore, according to Arctic Gas, no project of the size and scope of the Mackenzie Valley pipeline would be undertaken without a no-strike-no-lockout agreement.

Labour, for its part, supports Arctic Gas' contentions that construction can be carried out in the North throughout the winter. The industry-wide collective agreement spells out clearly the basic conditions such as the quality of food and accommodation. The individual project agreement spells out the working conditions for the actual project, based on the basic collective agreement for minimal conditions and on the perceived scope and complexity of the specific project for project-related details. In answer to Foothills' objections concerning men being unwilling to work below certain temperatures and over Christmas, members of the Canadian Pipeline Advisory Council (the labour-management organization comprising the primary pipeline construction unions and contractors) has stated clearly that a good agreement would make provision for such circumstances. It is also stated in their evidence that the agreements do not contain codes for such things as degrees of temperature or windchill below which no work will be conducted. Instead, it is decided on a mutual businesslike basis between the contractor and the union representatives according to weather conditions

prevailing at the time whether the men will go to work. Basic guarantees such as a minimum of 40 hours per week, overtime, standby pay and other conditions are, according to the unions, incentives to keep the work moving. All have stated their agreement with the standard project procedure of having a no-strike-no-lockout project agreement for the Mackenzie Valley pipeline.

Despite the various assurances, however, there are limits beyond which labour would not go. Union spokesmen have made this clear, giving as an example that efforts to run more than a few days longer than 12 hours to do small catch-up would be resisted.

If the Company fell far behind in its schedule, especially during the second winter, it would be under extreme pressure, just on the basis of the huge financial commitments, to increase the pace. Through various added incentives, labour could quite probably be persuaded to pick up the pace considerably. The pressure would be heaviest on other aspects of the project. Pressure would be put on the government to allow such things as working through or beyond break-up in the spring; summer work; easing of terrain, vegetation and wildlife protection measures to name but a few of the higher risk areas. Arctic Gas has maintained stoutly, under questioning from Foothills and the participants, that it would not be necessary to extend its construction season. Instead it could bring in more men and equipment, or extend the work load of each spread.

Neither Applicant has developed a contingency plan for the event of delayed schedules, however caused, although both have spoken generally of their willingness to accommodate early migrating caribou or other such unexpected phenomena. No allowance has been made for delays in the receiving of supply and materials required, nor for failure in the river transportation system or Beaufort Sea system, let alone for labour problems such as strikes, or even just the inability to find sufficient skilled labour for the project. One of the most severe problems, one which could delay the project from the very outset, is that of lack of snow for snow road preparation (see "Snow Roads"). The existence of a contingency plan, based just on the point of lack of snow alone, would seem to be an essential part of any application, let alone contingency plans for other misfortunes which could arise.

Resisting pressures brought to bear by the Company wishing to take shortcuts or change its basic plan in any way can only be

effectively done through early recognition of problems or potential trouble spots by the government through its field inspectors and regulatory agency. The key to solving the basic problem is avoidance through very careful and realistic planning and schedule development. This should be done around some proven analytical concept such as PERT (Program Evaluation and Review Technique) or CP (Critical Path) analysis.

Critical path planning or similar method is common on most large engineering projects. Both Applicants have indicated that they will be using such methods, although no choice has been made as to the specific method, or at which point in the project planning it might finally come into use.

One of the unique features of this pipeline project, however, is the need to consider "extraordinary" (non-project) events such as the early arrival of a caribou herd, the white whales, or of staging birds at the site of construction activity anywhere along the line. These events will place the same severe restrictions on construction activities as would labour problems, failure to receive crucial equipment or supplies, shortages of skilled labour, extreme bad weather for unexpectedly long periods of time, tc name a few of the events which can be planned for. While these latter events can be assessed in a normal plan and alternative courses of action laid out, some of the biological events may not be so amenable to standard planning approaches. On the pipeline project, however, environmental constraints must be given equal stature with other types of events and be incorporated into the project planning scenarios at the very beginning. The Applicants' own studies, submitted as background information to their applications, and the information available to both Applicants through the exhaustive hearings process, have underlined extensively the possibilities that fish, mammals, birds and local people will, in the course of their own natural cycles cf land and water use, preclude use of that land or water at certain times for construction of the pipeline or related facilities.

It should be possible for the Company to present detailed timetables, schedules and contingency plans for construction of the pipeline and every related facility. This should be a requirement of the Company, who will have to demonstrate an awareness of the environmental and the social constraints for all activities on each spread, and show some clear course of action to be taken for each constraint or combination of constraints imposed.

Every aspect of the Company's plan must be intensively scrutinized from the point of view of:

(a) need for contingency planning throughout; and

(b) the potential scheduling spillover which would lead to pressure to avoid or ignore some environmental, social or even basic safety constraint or restriction.

For example, Arctic Gas has stated that it will be able to move extra men in under certain circumstances, and augment the manpower on any given spread or spreads. However, original planning calls for construction camps to house 800 men. While assurances have been given that more men could easily - and comfortably - be accommodated in the spread camps, the plan would have to be thoroughly assessed from the point of view of such things as the adequacy ofwater supply and treatment and of waste and waste water disposal facilities. Thus, the design of each and every water and sewage treatment system for every camp will require careful analysis for:

(a) capacity and capability for the planned size of the camp; and

(b) for substantial population increase.

The particular problem of wastewater treatment facilities being inadequate for the job arose for and over again at camps in Alaska over the Alyeska Pipeline, partly because of inadequacies in original design, but largely through continual addition of men to already overcrowded camps.

Delays in construction activities will not only mean additions to the number of men on the line. For each man brought in to augment the work force, it will be necessary to bring in the requisite support materials and services. Thus, not only will flying in the additional men add to the number of flights in the area, but the flying in of the extra food, fuel and equipment will also add to the number of flights to be made to any given area at any time. It is most likely that the need for extra men will be discovered towards spring. Thus, any extra flight activity might well take place right at a crucial time for some wildlife activities. Extra flights will put more pressure on traffic control programs, on air strips and community airport facilities and on local operators, to name just one small, incomplete chain of consequences of a revised work schedule.

Thus, every contingency plan will have to be assessed from the point of view of all possible related activities and events. Furthermore, the mechanism for review must extend to include the constractors and sub-contractors. Any stipulations with respect to scheduling and logistics must apply to both the Company and all its contractors.

RECOMMENDATIONS

1. Upon receiving pipeline route approval, the Company shall demonstrate the technical feasibility and environmental acceptability of the proposed construction schedules and logistics by submitting to the Agency for approval:

   (a) preliminary construction and logistics plan for each spread; and

   (b) a preliminary contingency scheduling and logistics plan for each spread.

2. As part of its final design submission to the Agency and prior to commencing any work (apart from clearing) on any spread, the Company shall provide the government with a finalized sequential activity analysis, The analysis shall include all the activities related to construction and all the environmental and other constraints which might occur with the course of action (contingency plan) that will be followed if such constraints do arise.

3. During construction the Company shall prepare for the Agency a monthly construction progress report for each spread or part thereof as prescribed by the Agency. It shall describe:

   (a) construction progress to date on each spread keyed to an updated sequential activity program;

   (b) construction delays and proposed methods for overcoming these delays including a revised forecast of project scheduling and activities showing how all physical constraints and all stipulations will be met;

   (c) the physical conditions of snow and ice roads; and

   (d) any actual or planned additions to the work force accommodated in construction camps and other camps.

4. In order to enact scheduling and/or logistics modifications, or if the monthly progress reports show variations to the original activity plans, the Company shall submit a revised plan to the Agency for approval. In particular, the Agency may request the Company to submit a schedule on the basis of a worst case scenerio, as outlined by the Agency. The schedule shall show how the Company would deal with the worst case schedule and comply with the project stiuplations.

5. The Agency's field inspector shall have the authority to delay or close down work on a construction spread when schedules and logistics plans or activities deviate from the approved plans in a way which may lead to an environmentally unacceptable situation.

6. The Company must notify the Agency's field inspector of proposed activities at least 48 hours before the particular operation takes place. If monitoring is to be undertaken by an independent source, notification must take place 72 hours before the operation takes place.

SOURCES OF INFORMATION

1. Transcripts, Exhibits, Basic Documents

CAGPL	Dau, P.H. (33:4231-47, 4284, 4291; 34:4386-93, 4406-09, 4418-19, 4433-35; 35:4550-58; 37:2737-41, 4764-65, 4776-80; 38:4923-25, 39:5058-62, 5096-98, 5155-71, 5173-78; 68:10139, 10158); Williams, G.L. (38:4914-18; 68:10164; 86:12992-13001, 10313)
FH	Kosten, W. (65:9614-20; 66:9648-70, 9700-03, 9714-19, 9723-26, 9784-90, 9790-98); Mirosh, E.A. (65:9596-97; 66:9726-37; 67:9876-81, 9897-98, 9912-29, 9962-67)
CARC	Lent, P.C. (105:16159, 16168)
Unions (Private)	Canadian Pipeline Advisory Council & United Association of Plumbing and Pipefitting, St. Eloi, J.R. (180:27921, 28005); Marriot, R.F.C. (180:27921, 27960, 28012); Whiteford, J. (180:28008); Nessel, I. (180:28014, 28016); Building Trades Council, McCambly, J.A. (181:28402, 28050, 28077)

GRADING AND GROUND PROTECTION

GENERAL RECOMMENDATION

The Company shall endeavour to minimize disturbance to and destruction of the ground surface along the pipeline right-of-way by adopting an "arctic pipeline construction" technique and using snow roads to the greatest extent possible, and by minimizing as far as possible the amount of cut-grading, "conventional winter pipeline construction" and summer or fall construction from gravel work pads.

DISCUSSION

A considerable extent of severe ground disturbance along the pipeline right-of-way is inevitable. The primary cause of such disturbance is the actual excavation of the trench in which the pipe is laid and its backfilling. Secondary causes of disturbance include right-of-way cuts in areas of rough ground, at the crest of slopes and valley walls and in the banks of rivers and streams; grading for access roads, cuts for borrow pits and quarries, and grading for the construction of facility sites.

The disturbance accociated with borrow pits, quarries and facility sites is of less concern than that resulting from the grading of the right-of-way or roads. Borrow-pits and quarries, by their very nature, result in major reshapings of the landscape and so is a requirement for a major rehabilitation effort. Furthermore, pits and quarries needed for this project will normally be opened in materials that are neither erosion-sensitive nor thaw-sensitive. The facility sites are of less concern because their location can be adjusted somewhat to minimize their impact, and because the surface of the site will be protected by a pad of fill, capped with an erosion resistant wearing-surface of granular material.

The pipeline right-of-way and all the access roads are rather different in that they have to be continuous throughout their length. Thus they occasionally have to cross areas of bad or sensitive ground. Such areas can sometimes be avoided by changing the alignment generally with a concomitant

increase in the dollar cost of the project. In many cases, however, the problem areas cannot be avoided.

As some disturbance is inevitable, the objective of the terms and conditions must be to endeavour to keep the amount of disturbance within acceptable levels. This may be done by requiring constraints on the season of certain activities being undertaken, on the equipment used and on the manner of operations of such equipment.

With the exception of the northernmost 50 miles of the Foothills mainline, both Applicants have already proposed the first step in this minimization process, namely to construct their pipelines in winter. The advantages of winter construction are numerous, and they encompass many areas of concern outside the topic of this section. The direct advantages of interest here include the ground being frozen and snow covered, and so able to support the weight of heavy work equipment, the absence of running water in most streams and small rivers, the reduced risk of forest fire, etc.

Both Applicants propose to use essentially the same range of equipment in constructing the pipeline. This will all be standard pipelaying equipment except that more off-road vehicles may be used particularly in the construction of new roads. There is some difference in the manner in which the Applicants propose to construct different parts of their respective pipelines. Arctic Gas proposes to use a modified technique of pipelaying in areas of sensitive permafrost, the so-called "arctic" construction technique. In its applications, the proposal was to use this "arctic" technique generally north of about 65°N and conventional winter construction south of about 65°N. There was considerable discussion of this during the formal hearings, and Arctic Gas witnesses agreed there was more sensitive terrain further south than they had originally expected and that the arctic technique would be used wherever necessary.

Foothills did not distinguish between arctic and conventional pipelaying techniques in its application, or in the formal hearings. The general impression given was that Foothills proposes to use a "conventional" technique for much more of the pipeline than Arctic Gas. Foothills also proposes to clear and grade much of the right-of-way during the winter preceding the first winter of pipelaying. The only exception to this would be side hill areas in sensitive permafrost terrain.

Foothills' proposal to construct its northernmost 50 miles of mainline in fall from a gravel work pad has a considerable potential for ground surface disturbance. This will occur at the many breaks that will be left in the pad to provide for

surface drainage and streams to cross the alighment. Each of these breaks has to be filled in with a culvert before construction can commence, becuase of the need for men and equipment and supplies to move along the right-of-way. Each culvert then has to be removed and each break filled with gravel for the operations of trenching, lowering-in and backfilling. Each culvert is then replaced to allow for more travel, and finally each culvert is removed when all construction has ceased. The potential for severe damage to the ground at each break in the pad is obvious. Other disadvantages of this proposal are commented on elsewhere in this submission.

RECOMMENDATIONS:

1. In constructing the pipeline, the Company shall adopt techniques which minimze disturbance to or destruction of the ground surface vegetation mat. Company designs and construction methods shall minimize the uses of cuts and grading of the ground surface in all sensitive permafrost areas.

2. Construction of the pipeline north of 60^{o}N shall be done in winter from a snow work pad ("arctic" construction mode of Arctic Gas) and work from a graded right-of-way surface (conventional construction mode of Arctic Gas) shall be used only where authorized by the Agency (in answer to a Company request) in areas of stable ground.

3. Construction of the pipeline at any time of year other than winter (e.g. summer or autumn) and/or from a gravel-fill work pad shall be permitted only where approved by the Agency based upon a submission by the Company demonstrating the need for and advantages of this depacture.

4. As part of the final design, the Company shall submit detailed plan and profiles of the right-of-way indicating the construction method proposed for each part of the pipeline. This submissions should show:

    a) the depth and width of all cuts in the right-of-way;

    b) the width of the right-of-way that will be disturbed by grading, ditching, spoil storage and backfilling;

    c) the thickness and width of all fills and embankments;

    d) when, how and with what equipment each part of the pipeline is proposed to be built; and

    e) the general nature of all drainage and erosion control devices proposed for each part of the right-of-way

Similar plans and profiles should be submitted for all access roads, trails and shoo-fly roads.

The plans should be on a contoured orthophoto base, at a scale of not less than 1 inch to 1000 feet, with a contour interval of 5 feet. Similar plans should be provided for all facilities related to the construction and operation of the pipeline.

Comment: These specifications are taken from the proposals regarding final design alignment sheets made by Clark and Williams (29:3619-21). The availability of a contoured orthophoto mosaic is of considerable value in the design review for any transportation structure. It facilitates consideration of drainage problems, stream crossings, relationship of borrow areas to their surroundings, routing of access roads, relationship to swamps, wetlands and thermofrost areas, and the general aesthetics of the design.

5. Grading of the right-of-way shall not be done more than three months ahead of the construction of any section of the pipeline except where authorized by the Agency.

SOURCES OF INFORMATION

1. Transcripts, Exhibits, Basic Documents

CAGPL	Dau, P.H. and Harlan, R.L. (39:5106-14); Clark, J.I. and Williams, G.L. (29:3619-21)
FH	Bauer A.F. (65:8606-12; 67:9844-55, 9943-58); Kosten, W. (67:10025-26); Mirosh, E.A. (67:9844-55)
CAGPL	Application, Sections, 8.b.1.3, 13.a.6, 14.d.N.5.3.1, 14.d.N.7.2
	Responses, Questions 18 and 20
FH	Application, (as revised to 5 August 1976) Sections 3B-2, 3D-2.3, 5D-4.4.3
PAAG	Report, Sections 8.4, 8.5, 8.6 and 8.14

VEGETATION CLEARING

GENERAL RECOMMENDATION

1. The Company shall minimize the environmental impact from vegetation clearing to the right-of-way and adjacent areas by appropriate control and scheduling. The area cleared shall be as limited as possible, clearing methods shall be such that terrain damage is minimized and the time between clearing and the implementation of terrain stabilization measures shall be as short as possible.

DISCUSSION

The development of the gas pipeline and its associated facilities necessitates the clearing of trees from the lands to be used, principally the pipeline right-of-way. Although timber will be felled and habitat lost within those areas, the changes need not lead to any substantial environmental damage provided certain specified precautions are taken.

The proposed clearing procedures are of more serious concern, particularly the scheduling of clearing and the specific application of machine clearing. For instance, the clearing of the right-of-way a year or more in advance of construction will leave a disturbed surface exposed to at least a spring thaw and a summer melt. This is especially critical on slopes where terrain subsidence, slope instability and stream siltation could all result. It is important that the period between clearing and the beginning of pipeline construction be shortened as far as is practicable and that any activities such as grubbing or grading be delayed as long as is possible (<u>see</u> "Grading and Protection of Right-of-Way"). The differences between the proposed clearing procedures of the two Applicants are ones of scheduling and area cleared, and not generally technique. They are similar in that both will hand clear sensitive permafrost terrain and machine clear elsewhere. There may be problems in adequately defining sensitive permafrost terrain.

Canadian Arctic Gas will schedule its clearing the winter before pipeline construction if machine clearing is used and the summer before pipeline construction if hand clearing is used. Foothills, on the other hand, proposes only winter clearing. Hand clearing will take place immediately prior to pipeline construction whereas <u>all</u> machine clearing, with the possible exception of the most southerly spread, will take place the winter season before pipeline construction. This means that some sections of the

right-of-way will be cleared a full two years before pipeline construction begins. The Yellowknife-Pine Point community lateral, and possibly the most southerly construction spread will be machine cleared just prior to pipeline construction.

Foothills would clear a larger area than Canadian Arctic Gas. The mainline clearing requirements of the two Applicants would be roughly equal but Foothills has, in addition to the mainline, the fairly extensive clearing requirements for the Yellowknife-Pine Point community lateral.

The recommendations that follow are proposed to minimize the area disturbed because of clearing and to limit terrain degradation. They are not unique to the pipeline project but are a consolidation of the applicable conditions, with some modifications to meet the particular requirements of the pipeline, currently applied through various Land Use Permits and leases.

Preliminary Design

1. As part of the preliminary design the Company shall provide its plans for right-of-way clearing. These plans shall include information on:

    (a) the location of all areas to be cleared;

    (b) the methods proposed to clear these areas, including disposal;

    (c) the timing of clearing with respect to the pipeline construction schedule;

    (d) fire protection measures;

    (e) areas of merchantable timber, its harvest and disposal; and

    (f) interim terrain stabilization measures.

Specific Recommendations

2. All clearing boundaries to be marked prior to the commencement of clearing activities.

3. No vegetation shall be cleared from outside the clearing boundaries (with the exceptions noted in 4) and all blazed, pointed or posted trees which are on or within, or mark, clearing boundaries are reserved from cutting and removal.

4. Dangerous trees and snags with their base outside the clearing boundaries but leaning into the cleared area shall be removed using hand tools.

5. Only the minimum area necessary for the construction of the pipeline or any particular appurtenance shall be cleared.

6. Along those sections of the right-of-way where alternate access is required, the width of the right-of-way to be cleared shall be the full width (120 feet) less an amount equal to the width of the access road. Sections of the right-of-way where cuts are required are executed.

7. The cleared width of alternate access shall not exceed 50 feet.

8. Clearing may be performed either by hand or machine, subject to the provisions that follow. The methods chosen will be those which minimize disturbance of the surface vegetation and organic layer.

9. All bulldozer blades shall be equipped with mushroom shoes (except in those areas where grading will be allowed) and all equipment used in clearing shall be adequately powered.

10. The period between the initiation of disturbance by clearing and the implementation of erosion control procedures shall be as short as practicable. Clearing two winter seasons in advance of construction is not acceptable.

11. Where the right-of-way will be cleared a year in advance of construction, there shall be no clearing of vegetation from river and stream banks, valley walls and slopes greater than 6° except for that required to allow the movement of men and equipment.

12. The clearing of sensitive permafrost areas shall be delayed until just prior to construction.

13. Machine clearing will be restricted to the winter construction season and shall not begin before there is 8 inches of frost penetration and 4 inches of snow cover. The shutdown of clearing operations in the spring will be at the discretion of the Agency. Hand clearing can take place at anytime subject to prior approval by the Agency.

14. All clearing required for location surveys, and especially that required for the testing of borrow, shall be by hand.

15. Areas, such as the approaches to aircraft runways or the perimeter of compressor station sites, where no other activity than clearing is required, shall be hand cleared to minimize disturbance of the surface vegetation and organic mat.

16. All river and stream banks, valley walls and slopes greater than 6° will be hand cleared.

17. All vegetation at the tops of cuts will be hand cleared.

18. Winter trails and all other temporary access will be hand cleared.

19. There will be no traffic on unprepared surfaces during the thaw season.

20. No grubbing or disturbance of the ground surface (e.g. removal of the organic mat, levelling of hummocks etc.) to facilitate vehicle movement, either along the right-of-way or along access roads, shall be allowed during the clearing phase. Grubbing and grading of the right-of-way in areas of conventional construction shall not take place until the winter season of construction.

21. Where ground disturbance has occurred, inadvertantly or otherwise, interim stabilization measures may be required.

22. All trees, brush and other woody material cut in connection with the clearing operations shall be cut so that the resulting stumps shall be no higher than six inches measured from the ground to the uphill side.

23. Where clearing operations involve the cutting of merchantable timber (as identified by DIAND), the operator shall notify

the Agency of the amount, if any, which will be cut, removed, or destroyed in the construction of the pipeline system and shall pay the Government of Canada the sum of money the Agency shall determine to be the value of the timber to be cut, removed, or destroyed with the exception of that timber removed by local communities.

24. All merchantable timber shall be felled by hand.

25. Local communities shall have first refusal for any stands of merchantable timber that they might eventually have used had there been no pipeline.

26. Merchantable timber shall be cut and stacked. If not used within two years, such stacked timber shall be disposed of by burning.

27. No log landing shall be located within three hundred feet of any watercourse.

28. Logs shall not be skidded or yarded across any stream without the prior approval of the Agency.

29. There will be complete disposal of all trees, snags, brush and other woody material resulting from clearing operation, by burning, with the exception of survey lines and winter trails where lopping and scattering will be sufficient. The use of chippers may be authorized by the Agency.

31. The disposal of cleared woody material shall be concurrent with clearing except where there is summer clearing and burning would be hazardous. Disposal will then take place the following winter season.

31. The burning of slash, etc. shall be carried out on racks or sleds, designed for the purpose, or on rock surfaces, or any other such area where subsidence due to thawing will not occur. Burning shall be carried out under controlled conditions in winter when the fire hazard is negligible.

32. No burn area shall be located within 300 feet of a river, stream or lake.

33. All clearing debris that may block stream flow, hinder fish passage or contribute to flood damage as the result of stream

bed scour or erosion shall be removed and disposed of by burning. Wood chips or tree bark shall not be permitted to enter and shall not be deposited in any waterbody.

34. All residue from burning and all non-combustible waste shall be buried in spent borrow areas.

35. Clean-up of all areas shall be carried out to the satisfaction of the Agency.

SOURCES OF INFORMATION

1. Transcripts, Exhibits, Basic Documents

CAGPL	Marshall, J. (67:9931)
FH	Kosten, W. (65:9619; 66:9313); Mirosh, E.A. (66:9657, 9660, 9667; 67:9910)
CAGPL	Application (as amended to 8 March 1976).
	Consolidation Filing.
FH	Application (as amended to 23 August 1976).
PAAG	Recommendations.

2. Reports

Environmental Protection Board
1974 Towards and environmental code

SNOW ROADS

GENERAL RECOMMENDATIONS

The Company shall, for environmental reasons, use snow roads when operating in areas of permafrost and sensitive terrain.

The Company shall, where problems are encountered in the use of snow roads, overcome these problems by adjusting schedules, using alternate sources of snow, or other such means but not by abandoning snow roads for other procedures.

The Company shall construct, maintain and abandon snow roads in such a manner that disturbance of the vegetation and ground surface is minimized, that there be no diminution of aquatic resources and that there be no interference with wildlife.

DISCUSSION

Pipeline construction as proposed by both Applicants is dependent on snow roads. They form an integral part of the two construction plans and are necessary if terrain damage is to be limited to standards acceptable to government. There are still, however, fundamental concerns about their suitability in certain areas despite the considerable evidence presented at the Inquiry. These concerns are different from those relating to possible terrain impacts resulting from the use of such roads once constructed. There are two such fundamental concerns each of which has quite different implications. The first is one of scheduling and applies to both Applicants. In the more southern spreads the actual construction season, as determined by the availability of a suitable snow road, may be shorter than anticipated by the Applicants (EPB, 1974). The accommodation of this problem by the Company may require that the length of the construction spreads be shortened, or that additional crews and equipment be added or, where terrain and other environmental conditions permit, that another type of haul road and work pad be built.

The second concern involves the Mackenzie Delta and Yukon Coastal Plain, where snowfalls early in the season may not yield sufficient snow to build the haul road and the work pad required by the construction schedule. There is a variance of opinion on this. Weedon (CARC) has stated, on the basis of experience in Alaska, that Arctic Gas has not "... satisfactorily demonstrated the feasibility of its proposal in its application to construct [a snow road] on the Arctic Coastal Plain ..." (54:7546) because

precipitation in the region is light, especially early in the winter, Foothills has raised doubts about the ability of Arctic Gas to construct a snow road, when required, across the Yukon Coastal Plain (Williams, cr.ex. Gibbs, 131:19898-912, 19929-33) and about its own ability to construct a snow road in the Mackenzie Delta area (Gibbs, 131:19938). The Environment Protection Board has also said that there may be problems of physically constructing a snow road across the Yukon Coastal Plain (Adams, 107:13364).

Arctic Gas, however, is not relying on natural snowfalls but will harvest snow using fences (Williams, 34:4483) and, in the event of a shortage of snow early in the construction season, is prepared to manufacture 10 to 20 miles of snow road (Williams, 131:19903). The suitability of such snow fences and of snow manufacturing equipment to provide snow for the construction of snow roads has had only limited testing. There have been no tests at a scale and in a location similar to those required for pipeline construction nor has there been field research on the general subject of snow fence interference with wildlife (Jakimchuk, CAG, 96:14676). Such testing would seem to be required.

As the impact of the construction of the pipeline across the Yukon Coastal Plain and the Mackenzie Delta has been assessed on the basis of winter construction and the use of snow roads (Hemstock, CAG, 80:11918) Arctic Gas must demonstrate to the satisfaction of the government that it can complete the project in the way that it has proposed. Permanent roads and gravel work pads are considered to be environmentally unacceptable on the Yukon Coastal Plain and across the Mackenzie Delta.

In those areas where it has been demonstrated that the construction of snow roads is feasible, it is important to limit disturbance to the surface vegetation and the organic layer in order to avoid problems associated with permafrost degradation, terrain instability and erosion. Snow roads can be an invaluable aid in limiting such disturbance but the snow roads must be constructed, maintained and abandoned in such a manner that they themselves do not contribute to such disturbance.

Snow roads are not a feature unique to this proposed pipeline: they are commonly used now in the North, primarily in the support of hydrocarbon exploration. Pipeline snow roads, however, are unique in the standards to which they will be constructed and in

the volume and weight of traffic they will be required to carry. The haul road, designed to carry wheeled vehicles, will be constructed to higher standards than the adjacent work pad which will carry tracked vehicles only.

The major environmental concern stems from the Company's need to exploit fully the available winter construction season and to accommodate the year-to-year variation and uncertainty that occur in snowfall and other climatic factors. Appreciable terrain disturbance and environmental harm can be done in early winter if attempts are made to construct and use snow roads before frost and snow conditions are suitable. The same danger is present in the spring if roads are used past the point where they are able to protect the ground surface.

Considerable but unnecessary terrain damage could result during the preparation of snow roads if the Company adheres to a fixed schedule. Such schedules cannot take into account the variations in climate that occur between localities and successive years. Before the preparations can begin there must be sufficient frost penetration to support the vehicles and there must be sufficient snow cover to protect the surface vegetation. A complicating factor is the natural variability in frost penetration from place to place and year to year. Streams, drainage channels and other wet areas freeze more slowly than intervening areas and act as vehicle barriers delaying road preparation. The crossing of such drainage ways will have to be delayed until there is sufficient frost penetration to support vehicle movement or, if this is not possible, temporary crossing structures will be required.

Quantity of snow may also be a limiting factor in some areas in some years. Where meteorological records indicate that snowfall may be inadequate to construct a suitable road, snow harvesting will be necessary. Two methods have been proposed: the erection of snow fences to accumulate drifting snow and the "gathering" of snow from lake surfaces. Such snow harvesting is of some environmental concern in that snow fences could interfere with wildlife movements and vehicle access to lakes could cause bank degradation. Snow manufacturing, which can also be used to supplement low snowfalls at the beginning of the construction season, is of environmental concern relative to the effect of water level change on fish and aquatic wildlife.

Limited but acceptable impact to the vegetation and terrain is expected from the use of the snow roads during pipeline

construction provided that these roads are regularly maintained and repaired. It is important that direct contact between vehicles and the ground surface be limited, especially on slopes and valley walls where such disturbance could lead to terrain instability.

The greatest concern lies with the cessation of construction activity and the abandonment of the snow road in the spring. The Company will request, and not unreasonably, to be allowed to use the snow roads as late as possible in the spring. This requirement should be accommodated by the Agency but without jeopardizing the environment in any way. The difficulty in this is that any shut-off date of pipeline construction activity is dependent on the weather and this varies from year to year. The Company will be required to respond to an anticipated shut down date based on limited historical data and to an absolute shut down date based on actual snow road conditions. Good planning is critical at this stage because not only must construction activity cease rapidly and without environmental harm, but the snow road itself must be left in such a way that it does not channel or concentrate overland flow or interfere with the break-up of streams and rivers.

There are no fundamental differences between Arctic Gas and Foothills in the methods of construction of snow roads and the uses to which they will be put. Foothills, however, expresses much less dependence on snow roads for the completion of the project than does Arctic Gas, especially in the Mackenzie Delta region where snowfalls may be inadequate.

RFCOMMENDATIONS.

<u>General</u>

1. Construction of any part of the pipeline within the discontinuous and continuous permafrost region shall take place in winter from snow working surfaces and snow roads, except where some different logistic mode is approved by the Agency.

2. Any pipeline approved for construction on any part of the Mackenzie Delta (the modern river delta) or on the Yukon Coastal Plain west of the delta shall be built only in winter from snow working surfaces and snow roads. That is, the construction mode shall not differ basically from that

presently proposed by Arctic Gas and use of gravel pads and gravel roads shall not exceed the limited scale involved in the present Application. On no account shall a gravel work pad be built along the right-of-way or any gravel road be built along or to the pipeline route.

3. The use of the Fort Simpson-Inuvik winter road, if required in support of pipeline construction, shall be without major modification to routes or grades and without cuts, grading, widening or relocation. In its present form this winter road is not suitable for major pipeline transport

Preliminary Design

4. As part of its preliminary design submission, the Company shall provide convincing evidence that the required snow roads along the Yukon Coastal Plain are technically feasible and environmentally acceptable. As part of this demonstration, the Company shall conduct tests of snow harvesting using fences on the Yukon Coastal Plain for at least three consecutive years. Some aspects to be considered are: orientation of the fences; time and rate of snow accumulation; harvesting techniques that minimize surface disturbance; spacing; removal of fences prior to spring melt; and rehabilitation procedures. A demonstration of road building capability using snow manufacturing equipment shall also be included.

5. Prior to the commencement of final design the Company shall submit for Agency approval a preliminary design for all snow work pads and winter trails required for the project documenting:

(a) the location of all snow roads, snow work pads, winter trails and stream and river crossings (in map form) required for the project;

(b) a general Overall Plan for all water withdrawals required for snow road construction as specified in "Water Supply and Intakes";

(c) the design standards to be applied, including those for stream and river crossings, and the suitability of these for their specific purpose; maximum grades and limits on vertical and horizontal curvature shall be specified; and

(d) the design rationale that was used in determining the design standard and location for each snow road type.

<u>Specific Design</u>

6. Snow road plans will be approved separately for each construction spread. The following information will be submitted to the Agency:

(a) the exact location of all snow roads, potential water sources and lakes to be used for snow harvest, shown on photo-mosaic maps (scale 1":1000'); and include access trails to water sources and snow harvest lakes as well as the probable location for snow harvest fences;

(b) the methods and equipment to be used for right-of-way preparation (including enhancement of frost penetration), snow harvesting and hauling, snow compaction and ice capping;

(c) the expected date when snow road construction can begin, the date the snow road is required for use, and the flexibility in this latter date;

(d) the nature, number and location of wet areas (including but not exclusively, rivers and streams) that must be crossed when constructing snow roads, the construction methods to be used to cross those areas, and the required crossing date for each area;

(e) the dates when snow harvesting from lake surface is to begin and the amounts of snow to be harvested; this shall include information on equipment logistics, access routes to each lake and lake margin, and rehabilitation procedures, especially for damaged lake margins;

(f) the date and method of placement of snow fences, wildlife protection measures, snow harvesting techniques, the date and method of snow fence removal, and rehabilitation procedures, both for terrain damaged because of vehicle activity during harvesting and for erosion resulting from increased run-off;

(g) the access routes to all water sources required for snow road construction and equipment logistics, especially those for snow manufacturing equipment;

(h) the methods and equipment to be used for ice bridge construction, including the approaches;

(i) the methods and equipment to be used to maintain the snow roads;

(j) the dates for the termination of use of each road at the end of the winter construction season, and the detailed procedures that the Company will apply to terminate their use; and

(k) the abandonment procedures to be applied to snow roads when their use is terminated to ensure that river and stream crossings do not interfere with normal break-up and that overland drainage is not blocked or concentrated. Rehabilitation procedures shall also be specified.

Performance Criteria

7. Winter road preparation shall not begin before frost has penetrated at least 8 inches into the ground and 4 inches of snow has accumulated. However, the acceleration of frost penetration may be permitted by the Agency when there is 4 inches of natural frost penetration and 4 inches of snow cover. Equipment type and use must be approved by the Agency.

8. An Agency approved temporary crossing structure is required for all crossings of unfrozen streams, either during the preparation of snow roads or during the construction of the pipeline. There will be no passage of vehicles through stream beds.

9. Equipment required for the manufacture of snow for road construction must be placed and used without causing terrain damage.

10. Water use must be from an approved source (see "Water Supplies and Intakes").

11. Fences required for the collection of snow shall be placed in such a manner that they do not interfere with wildlife movements. Such fences will be removed by the completion of each construction season; no fences will remain in place across a summer season.

12. Access to lakes for the purpose of snow harvesting or to lakes or streams for water removal must be done in such a way that damage to margins and banks is limited. No cuts will be allowed and all fills must be made of snow or ice or both. Terrain damage must be repaired as soon as practicable (see also "Water Supplies and Intakes").

13. Snow roads must have a compacted thickness of 10 inches and a density of 0.6 gms. per cubic centimeter or greater before full wheeled traffic will be allowed. In areas of hummocky terrain the compacted snow depth will be measured from the crest of the hummocks.

14. Stream crossings, other than temporary bridges, shall be made of snow or ice or both. No earth, timber, or brush shall form any part of such a crossing.

15. The snow roads will be maintained to prevent contact between vehicle wheels or tracks and the ground surface.

16. The Company shall begin the termination of its winter construction activities on a week's notice and shall be prepared to cease all construction activity on 48 hours' notice.

17. The Company shall remove all material, plant and equipment from the work area prior to abandonment of the winter road. Should such removal be impossible, the Company shall store such material, plant, and equipment in a location approved by the Agency. Such material, plant and equipment shall not be moved from such an area without the prior approval of the Agency.

18. All crossings of minor streams and rivers shall be removed prior to break-up.

19. The snow road will be cross-ditched in areas where the concentration or diversion of overland flow in spring could result in erosion.

20. Terrain damaged during the construction, operation and abandonment of the snow road will be repaired the following summer.

SOURCES OF INFORMATION

Transcripts, Exhibits, Basic Documents

CAGPL	Hemstock, R.A. (80:11918); Jakimchuk, R.D. (96:14676); Williams, G.L. (34:4483; 86:13046; 131:19898-912, 19929-33)
FH	Gibbs, R. (131:19938); Jarvis, P. (66:9827-31)
CARC	Weedon, R. (54:7546)
EPB	Adam, K. (107:13364)
Comm.C.	Longlitz, D. (72:10722-31)
CAGPL	Application (as amended to 8 March 1976)
FH	Application (as amended to 23 August 1976)
PAAG	Report

GEOTECHNICAL CONSIDERATIONS

DISCUSSION

Within the terms of reference of this Inquiry geotechnical considerations provide a four-fold basis of concern:

a) the engineering feasibility of the pipeline;

b) a potential for pipeline breakage;

c) a potential need for construction of remedial or protective measures on a threatened portion of the pipeline; and

d) acceptable engineering performance that is socially or environmentally undesirable.

Feasibility is at stake when the solution to an engineering problem results in unacceptable costs, or alternatively excessive maintenance. In the matter of the proposed pipeline, the question of feasibility is a direct outcome of lack of precedent. For instance, there is no large scale precedent for a chilled gas pipeline. The proposed pipe is expected to heave differentially as it passes through several hundred miles of discontinuous permafrost. Arctic Gas has undertaken an extensive laboratory and field research program, which is still underway. The mechanism and extent of this heave has been the subject of much debate during the Inquiry and Arctic Gas has recently (7 October 1976) reported a laboratory malfunction that has opened up additional questions. Fundamental differences in opinion still remain. The alternative proposal by Foothills reflects this wide difference in opinion. Its proposal to cease to chill the pipe further north leaves open the possibility of large scale degradation of ice-rich permafrost along the route. Arctic Gas has argued against the Foothills proposal and has indicated in the NEB hearings that (in the light of new drilling results) it is considering moving its southern limit of chilling even further south. No one has seriously argued that a gas pipeline cannot be successfully built and operated within the Mackenzie Valley; it is a matter of determining the limits within which the pipeline must be designed and built to ensure acceptable performance.

Prediction of probable pipeline breakage frequency, 1-in-10 years (CAGPL, Responses, Qu. 22, p.22-1 to 22-3), is based primarily on statistics from non-permafrost areas for the operation of warm gas lines. Such statistics do not necessarily apply to the

operation of a chilled gas pipeline in permafrost areas. The chief consequences of pipeline breakages are:

a) interruption of gas supply;

b) ignition and explosion problems;

c) increased maintenance costs; and

d) emergency repairs to the line which, if carried out during thaw seasons or seasons when wildlife is senstitive to disturbance, could result in environmental damage.

Items (a) and (c) are outside the terms of reference of the Inquiry. Item (b) is reported to be readily controllable. The discussion of Item (d) at the Inquiry has centered around two points. The first is that the pipeline should be engineered and constructed so as to avoid any unnecessary maintenance. The second is the importance of a good monitoring program, so that a developing problem could be detected, thus permitting repairs or remedial action to be planned ahead.

There are several circumstances which, although acceptable from a geotechnical viewpoint, are socially or environmentally undesirable. For example the development of the frost bulb around the chilled pipe could interrupt drainage and cause permafrost degradation, or it could result in the blockage of low winter flows or downstream pools in creeks in which fish may overwinter. Many of these problems are avoided or mitigated by route changes.

GENERAL RECOMMENDATIONS

The following recommendations relate to geotechnical matters in general, and cover those questions dealt with in greater detail in the sections of this report entitled "Frost Heave and Thaw Settlement", "Slope Stability", and "Pipeline Uplift Problems Unrelated to Freezing".

1. A geotechnical review board consisting preferably of three experts, should be appointed by the Agency and should be charged with review of all engineering works, detailed design, construction procedures, field organization, and

monitoring methods involving matters lacking precedent and experience. Emphases in qualification of experts comprising the board should be depth of experience and overlapping broad background. The board should include:

a) an engineer familiar with cold region geotechnical and hydrological problems relevant to design and construction of the proposed pipeline;

b) an earth scientist familiar with surface and subsurface conditions along the pipeline route and their geotechnical implications; and

c) a gas transmission engineer with extensive background in design, construction, and pipeline contract administration.

2. In view of the lack of precedent and limited knowledge of actual field conditions relative to various geotechnical aspects of the pipeline project, the approach to design, construction methods and control should be more conservative than is usual in normal pipeline engineering practice. In particular, the Company should adopt (and be required to so demonstrate) contigency planning throughout.

Comment: Lack of precedent applies from the basic principle of chilling gas to minor design and construction techniques. It also applies to many other aspects of the project not covered by this report. Although no-one has seriously questioned the engineering feasibility of the project as generally proposed, there are many uncertainties and unresolved conflicts over details. It is apparent that some of these uncertainties will remain at the start of construction, and some will only be resolved with observation of pipe behaviour during operation.

3. In situations where important engineering decisions have to be reached using empircal formulas based upon laboratory tests or interpretation of poorly known site conditions, without the benefit of past experience with similar field prototypes, the Company shall demonstrate the sensitivity to error of the basis of such decisions. Where the basis for a decision is error-sensitive, its reliability should be thoroughly established through cross-checking.

4. Although every effort should be made to obtain as much data on surface and subsurface conditions as is practicable prior to construction, it is inevitable with a pipeline of such length and because of the remoteness of the area that much important design change information will be revealed during construction. This being the case, the design phase should be considered as running into and parallel with construction, to be terminated only at the end of construction. The Company should establish workable and fruitful liaison between those responsible for design and those responsible for construction. It should be required to demonstrate that the design concept with all its engineering and environmental implications is in fact being carried through into construction.

5. The project obviously will need a well selected and organised field team for inspection and construction control. Bearing in mind the considerable number of people required on this team and the seasonal nature of the construction schedule, there will be very real problems in obtaining and keeping qualified personnel. The need to develop on the one hand a reliable system of checking the work to be carried out by this team, and on the other hand to render their work as error-proof as possible by conservative design, is readily apparent. The Company plans in this regard should be received by the geotechnical review board.

   It will be necessary to establish an educational program to ensure that all field personnel fully appreciate the importance and significance of the observations they are required to make.

   Further it is essential, bearing in mind the proposed rapid pace of construction, that an appropriate and reliable means of expediting desirable design changes be established. It is expected that this would be done through a field design staff without recourse to a distant design office, except for major design changes.

6. Prior to final design, the Company should adjust its route and locations so as to minimize the length of the pipeline that crosses terrain which is potentially troublesome in terms of frost heave, thaw settlement, slope stability, buoyancy control, and erosion.

SOURCES OF INFORMATION

The following list covers information sources for this paper and those following entitled "Frost Heave and Thaw Settlement", "Slope Stability", and "Pipeline Uplift Problems Unrelated to Freezing".

1. <u>Transcript, Exhibits, Basic Documents</u>

CAGPL — Clark, J.I. (29:3585)
Application: Sections 8,9, 13a and 14d.N. Responses

DIAND — North of 60: Mackenzie Valley Pipeline Inquiry, Summaries of Proceedings.

MIPI — Prepared Testimony; Phase I; Engineering and construction of the proposed pipeline.

PAAG — Report

2. <u>Reports</u>

Canada 1975 — Industry, Trade Commerce
Visit to USSR of a group of Canadian experts representing the pipeline and the production and processing sub-groups of the gas working group of the Soviet Canadian Mixed Commission on industrial application of science and technology

CAGPL
1976a — Detailed summary of Arctic Gas test holes station ME-13 to M-21, East Simpson Route; Evidence submitted to NEB. (exhibit N-PD-362).

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1973 Interim report No. 3; Towards an environmental Impact Assessment of the portion of the Mackenzie gas pipeline from Alaska to Alberta; Appendix IV; Geotechnical and hydrological studies; pp. 53-57.

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1976a N.E.S. response of June, 1976 to Dr. Williams' March, 1976 report.

1976b Additional information on frost heave supplied by N.E.S. pursuant to N.E.B. requests of May 11-14, 1976.

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1973 Encountering massive ground ice during road construction in central Alaska; in North America contribution to second International Permafrost Conference, Yakutsk, pp. 730-736.

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1975 Preliminary review of the geotechnical aspects of CAGPL design of a buried chilled gas pipeline, pp. 83-90.

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FROST HEAVE AND THAW SETTLEMENT

INTRODUCTION

Over a significant part of some 800 miles of pipeline through the discontinuous permafrost area, both Applicants propose to refrigerate the gas and operate the buried pipeline at temperatures below the freezing point of water. Chilling of the buried pipeline in unfrozen frost susceptible soils will cause freezing and formation of ice lenses around the pipe and, hence, an upward heave of both the pipe and the ground in the vicinity of the pipe.

It is generally agreed that:

a) the phenomenon of frost heaving applies to a significant length of the proposed pipeline,; and

b) a buried chilled pipeline through discontinuous permafrost is an unprecedented project.

A review of the information available to the Inquiry in regard to frost heave and thaw settlement, as they relate to the construction and operation of the proposed pipeline indicates concerns within the following areas:

a) the prediction of frost heave and the effectiveness of the proposed preventative and remedial measures;

b) the location of the limit of chilling;

c) the confirmation of design assumptions during construction;

d) the monitoring of frost heave after construction; and

e) the effect on surface and subsurface drainage.

This paper deals with the first four of these five concerns. The fifth, involving effects on drainage is covered under "Crossings: Design Criteria" and "Drainage and Erosion Control".

PREDICTION OF FROST HEAVE AND EFFECTIVENESS OF PREVENTATIVE AND REMEDIAL MEASURES

DISCUSSION

Arctic Gas has undertaken a series of laboratory tests and a full scale field test in Calgary, to study the frost heave phenomenon. From this information it has derived an empirical set of equations which it believes encompass the significant parameters governing frost heave (NEB Responses, V. IV, L.4, Q.2, App.G). The study reveals that the growth of ice lenses at the frost front is governed in part by the effective stress at the frost front. Once a critical effective stress is reached (the shut-off pressure) ice lenses will not grow at the frost front. The shut-off pressure varies with soil type but has apparently been determined for the range of soils likely to be encountered in the field.

Note 1: On 7 October, 1976, Arctic Gas informed the Inquiry of a basic error in their laboratory testing equipment which would affect the validity of the tests in predicting the shut-off pressure for various soil types. In further evidence given on October 15, N.E.S. stated the error was on the unsafe side, leading to apparent shut-off pressures significantly lower than the correct values.

The Applicants recognize that differential heave is the most important consideration having regard to the adverse effects of heave on the pipe. Arctic Gas has carried out a parametric study (NES, Mechanical, Stress Analysis of Buried Pipeline, Vols. 1-3) which indicates that the time to reach the critical differential heave (at which the rupture would occur) is a function of length of heave section and the uplift resistance of the frozen ground at each end of the heave section. The study indicates that the minimum time to rupture, assuming frost heave is not controlled, would range from about 8 months to several years. Assuming the emirical method for predicting frost heave and shut-off pressures is valid, the study concludes that surcharge loading would be an effective technique to limit differential heave to acceptable amounts.

It is, of course, not necessary to eliminate heave.

<u>Note 2</u>: The faulty laboratory test results for shut-off pressure announced by Arctic Gas on 7 October, 1976 have been used in preparing the emperical equations which in turn are used for predicting field shut-off pressures and the selection and design of control measures. The validity of the empirical equations is thus questionable, adding uncertainty to the use of deep burial and surcharge as a means of controlling frost heave.

Based on this understanding of the frost heave problem, both Applicants have proposed the following preventative and remedial measures to limit the effects of frost heave:

a) Surcharging the ground surface with a berm so that the overburden pressure at the frost front below the pipe approaches the shut-off pressure.

b) Burying the pipe to greater depths so that higher effective pressures are achieved at the frost front.

c) Excavation of frost susceptible material and replacement with non-frost susceptible material.

d) Use of insulation around the pipe along with granular backfill below the insulation is being considered by Foothills (NEB, 6692-93). Arctic Gas is also considering this procedure for special circumstances (e.g. deep peat deposits).

e) Dual pipelines at river crossings so that gas flow can be run alternatively between each pipe (CAGPL to NEB, May 1976, p.23).

f) Locally increasing the temperature of the gas to relieve the stresses from frost heave (NEB, 5712-74).

g) Localized freezing to accelerate the growth of the frost bulb, so that the frost front beneath the pipe rapidly penetrates to a depth where the overburden pressure is in close proximity to the shut-off pressure (29:3585).

h) Use of slip joints or pliant clay around the pipe, to reduce pipe stresses where unavoidable critical differential heave is anticipated (NEB, 2685, 2841, 3817-18).

Both Applicants propose to use measures (a) and (b) extensively and the remaining measures are being treated as alternate contingency terms. It is apparent that all of the above techniques have practical limitations and laboratory or field data to indicate their effectiveness is limited and, in some cases, non-existent.

The Applicants plan to identify areas of potential heave along the route prior to construction and decide on the type of measure to limit frost heaving at specific locations. They have characterized a number of terrain types with respect to potential for frost heaving and this work is to be continued. They then propose to determine the distribution of unfrozen soils along the route by geophysical profiling immediately after right-of-way clearing (NEB 2690, 2838). Arctic Gas claims that its geophysical profiling has proved successful in distinguishing between frozen and unfrozen ground (NEB 2689; CAGPL to NEB, May 1976, p. 13).

There are three major concerns with regard to the Applicants' prediction of frost heave and the proposed methods for dealing with the problem.

a) The concept of "shut-off" pressures is central to the Applicants" approach of predicting and limiting frost heave. The validity of the method for predicting shut-off pressures under various terrain conditions and the effectivness of the measures proposed for reducing the heave are major concerns.

<u>Note 3</u>: The announcement by Arctic Gas on 7 October, 1976 that the laboratory test results for shut-off pressure are faulty reinforces these major concerns (see also Notes 1 and 2).

There is, unfortunately, no long term support data available. The Calgary test site data is relatively short term and has not conclusively demonstrated to-date that deep burial with berming or replacement of frost susceptible material are

adequate preventative measures (NEB Exhibit N-PD-370). The shut-off pressures in the various test sections have still to be reached (NEB 5043;44). The restrained section gave an initial indication of approaching the shut-off pressure with decreasing heave when the frost bulb penetrated from 10 to 14 feet depth but the results were complicated when an increase in the rate of heave was observed in December 1975. Arctic Gas believes that the frost bulb at this time started to penetrate more frost susceptible soil with a higher shut-off pressure (NEB, 5043-44). It is a fact, however, that, notwithstanding the availability of the detailed information of the soil conditions at this relatively small test site, this performance was not anticipated.

b) Insufficient field data has been obtained to-date to establish the locations at which the critical conditions for differential, heave will be encountered in the field (NEB 2837-39). It is uncertain that the worst conditions are understood and appreciated, and have been allowed for in the analysis to-date.

c) No full scale tests have been carried out to assess the problem of differential heave. The Calgary field tests were conducted in near-homogeneous soils and total heave only was measured. Concern has been expressed that the developing frost bulb in the prototype would have strong and weak sections depending upon the heterogeneity of the soil conditions, and that any pipe deformations would be concentrated in the weak sections.

The consideration given to the various measures for reducing or coping with frost heave is imbalanced. Greatest emphasis has been placed on measures (a), (b) and (c). In particular the performance of an insulated pipe as proposed by Foothills (NEB 6530) is sensitive to design and construction errors and possible deterioration of the insulating material. The design philosophy is to limit the penetration of the frost front to a depth of approximately 2 1/2 feet below the insulation and where necessary replace the soil within this depth range with non-frost susceptible material (NEB Exhibit N-PD-419; NEB 6693). Should, however, the frost front penetrate beyond the design depth (i.e. beyond the gravel) into frost susceptible material, the resulting total and differential heave could be greater than would have been experienced without the insulation (because of the relatively low overburden pressure and closer proximity to the

pipe). The initial performance of such a faultily insulated pipe could be deceptive in that it could take several years for heave problems to develop, and then they could develop rapidly.

Although it is generally agreed that ice lensing and heave can also occur in frozen soil (i.e. behind the frost front), experts disagree on whether this phenomenon is of engineering significance to the pipeline over the long term (Williams, 1976; NES, 1976, Response to Williams, 1976). The study of water migration in frozen soils is in its infancy, and the widely differing opinions expressed during the Inquiry result in part from lack of knowledge.

If the empirical approach for predicting shut-off pressures is incorrect on the unsafe side, or the worst conditions are not appreciated, then the proposed preventative measures used to limit heave may not be adequate. In areas where differential heave is of concern, this could result in increased pipe maintenance to pipe breakage (in extreme cases), the consequences of which were described earlier.

The selection of a preventative measure would be based, in part, upon the prediction of shut-off pressures. Thus an erroneous prediction could result in the selection of an unsuitable preventative measure.

It is possible, without adequate field testing, that a preventative measure could aggravate a condition it was designed to prevent. Further, as in the case of a faultily insulated pipe, a major problem could, in effect, lie dormant for several initial years of operation, and thus would be "unexpected" when it eventually surfaced.

The available information indicates that, provided the performance of the pipe is adequately monitored, there should be adequate lead time to take corrective action. It is thus important to establish an acceptable schedule for monitoring.

RECOMMENDATIONS

1. In view of the uncertainties and concerns about frost heave and its control that have been described in this section, it is recommended that all design and construction procedures relating to frost heave and any changes thereto be independently reviewed by the geotechnical review board

proposed in the foregoing section, and that for this purpose the board be supplemented by a physicist thoroughly versed in the processes by which soil freezes. Moreover, approval of final design by the Agency should be conditioned upon a favourable report by the board concerning frost heave control.

2. Unprecedented issues are involved in the geotechnical aspects of the engineering and construction of the pipeline. As such the detailed experience gained by NES and its consultants is unusually valuable both in itself and as a base for further necessary investigations and studies. It is in the interests of everyone that those ultimately responsible for building the pipeline should make a bonafide effort to utilize these experienced personnel. Notwithstanding this recommendation, the Inquiry has shown first hand the merits of inter-mixing and "fresh blood".

3. The pipeline engineers should adopt a cautious approach to ensure a suitably conservative design. The design and construction contract arrangements should be flexible to permit substantial changes as understanding of the field conditions and related problems improves.

4. The Calgary full scale field tests should be continued until they demonstrate conclusively that over the long term the various preventative and remedial measures used at the test site can reduce pipe heave to acceptable and predictable amounts.

5. The data obtained from the Calgary test site should be reviewed on an ongoing basis and the design methods refined accordingly.

6. It is recommended that other preventative and remedial measures, such as items (d) to (h) in the list at the beginning of this section, be given thorough technical and economic consideration. The alternative of elevating the pipe above ground when heaving cannot be readily controlled should also be included.

7. Appropriate additional laboratory tests should be conducted to assess the significance of frost lens growth behind the frost front.

8. In the light of the announcement by Arctic Gas on October 7, 1976 that the laboratory tests for shut-off pressure are faulty, it is further recommended that additional laboratory tests be carried out to correct the effect of the erroneous tests and re-evaluate the empirical equations as they affect the feasibility of berming and burial as a form of heave control.

9. It is necessary to complete the field drilling program and the geophysical profiling prior to completion of detailed design. It is further recommended that micro-scale (detailed) subsurface investigations be carried out at typical locations where severe differential heave is anticipated.

10. The performance of the pipe should be monitored on a routine basis in accordance with an established schedule. This schedule should allow for frequent inspections (see following paragraphs on "Monitoring of Frost Heave After Construction") during the first year of operation. The frequency of monitoring could be reduced thereafter, depending on the observed behaviour.

THE LOCATION OF THE LIMIT OF CHILLING

DISCUSSION

The primary purpose of chilling the gas below the freezing point of water is to prevent permafrost regression and the associated environmental and thaw-settlement problems. In northern areas where the pipeline passes predominantly through ice-rich permafrost, the potential problems due to thawing of the ground would far outweigh any problems due to frost heave in occasional segments of unfrozen ground. In such areas there is little question of the merit of chilling the gas. In the southern part of the discontinuous permafrost zone, the percentage of unfrozen material along the pipeline route increases to the point, where potential problems due to frost heaving outweigh the problems associated with the thawing of the permafrost. It is thus necessary to establish a geographical limit of chilling which is in effect a trade-off of the problems resulting from chilling and the problems resulting from thawing of permafrost. Neither Applicant has made a final decision on the location of the limit of chilling.

Arctic Gas has indicated that based on recent drilling it may decide to move the tentative location of the limit of chilling south from MP 670 to MP 751 (NEB 1981-82). In this case the gas temperature would remain below freezing to a point approximately 50 miles south of the NWT-Alberta border (i.e. MP 870). Some 152 test holes have been drilled along the East Simpson Route (NEB Exhibit N-PD-362) between MP 600 and MP 900, and roughly half of these holes encountered permafrost, sometimes with high ice content. However further work is needed to establish the proportioning of the route with regard to frozen and unfrozen terrain. Also the characteristics of the terrain with regard to frost heave problems on the one hand and thaw settlement on the other, need to be determined.

Foothills has reported that its tentative location for the limit of chilling is MP 688 (MVPI, Summaries, Vol 21, p.2). Drilling and terrain analysis from this point towards the Alberta border for a distance of approximately 100 miles, has indicated that one third of the route is in permafrost, some of which can be expected to have high ice content. Foothills' consultants have stated that little is known about the ice-rich terrain and they recommend more exploration (EBA, "Terrain Study and Thaw Settlement Analysis, MP 678-784").

It is apparent that Arctic Gas believes that solving thaw settlement problems from Fort Simpson to the N.W.T.-Alberta border along its route will be more difficult than solving frost have problems. Consequently, it proposes to chill the gas in this section.

Foothills, on the other hand, believes that along the route it has selected in this area, thaw settlement problems will be easier to handle (MVPI, Summaries, Vol. 21, p.3).

Neither Applicant appears to have sufficient field information on which to make a final decision regarding the optimum location for the limit of chilling. It is possible that sufficient information will not be available until construction commences and further information is obtained from an examination of the trench walls.

Neither Applicant has clearly demonstrated a "trade-off" approach designed to mitigate the adverse effects of chilling and not chilling. Arctic Gas has stressed investigation of the problems of chilling, but has put relatively little effort into

investigating measures for reducing the impact of thaw settlements and associated drainage disruptions and environmental damage. Other than to suggest the removal of frozen peat (EBA, "Terrain Study and Thaw Settlement Analysis MP 678-784"), Foothills also has not demonstrated how it would cope with problems of thawing permafrost.

There is evidence that problems resulting from permafrost thaw could occur over a longer period of time (and thus incur greater maintenance) than those associated with frost heave. Arctic Gas claims that most heave will occur during the initial 4 to 6 years of operation. Foothills has theoretically shown that less than half of the ultimate settlement of the pipe due to thawing permafrost can occur during the same period of operation (EBA, "Terrain Study and Thaw Settlement Analysis MP 678-784"). Further, surface ponding (caused by settlement) more adverse thaw conditions than those predicted.

The selection of an erroneous location for the limit of chilling would probably result in significantly more maintenance being required for this portion of the line, than would otherwise be necessary. In addition, environmental damage may be significantly greater than would otherwise be necessary.

RECOMMENDATIONS

11. The completion of detailed exploration (drilling and terrain analysis) of that portion of the pipeline route between MP 670 and 870 needs emphasis. Those areas where significant thaw settlement and significant frost heave could occur should be reliably identified.

12. Measures for reducing the impact of thaw settlement, associated drainage problems, and resulting environmental damage need to be critically studied in detail. Where necessary, supporting field tests should be carried out.

13. Based on the above, a tentative location for the limit of chilling should be <u>conservatively</u> selected from the standpoint of detailed design and fabrication of equipment. This is a location south of which the need for cooling equipment is considered remote, using a pessimistic interpretation of thaw settlement problems.

14. The final decision of the location of the limit of chilling should be postponed until construction, when additional detailed soils data will become available.

15. The design of the cooling equipment should be such that the location of the southern limit of gas cooled below 0°C can be modified depending upon the observed behaviour of the pipeline under operation.

<u>CONFIRMATION OF DESIGN ASSUMPTIONS DURING CONSTRUCTION</u>

DISCUSSION

Arctic Gas proposes to prepare design manuals and tables which will specify the depth of burial and height of berm depending on terrain type, line temperature etc. (NEB 2585). However, it will not be possible to anticipate all terrain conditions prior to start of construction. A design-change manual is, therefore, proposed by Arctic Gas which will be available prior to start of construction. This manual is intended to account for most necessary changes where actual conditions differ significantly from those envisioned prior to construction. Arctic Gas also intends to determine locations where permafrost is not present by undertaking geophysical profiling shortly after the pipeline right-of-way has been cleared (NEB 2689, 2690, 2838; CAGPL to NEB, May 1976, p.13). In addition Arctic Gas proposes to catalogue permafrost and soil conditions adjacent to and along the right-of-way and to record geotechnical conditions in the ditchwall on a mile-by-mile basis. The frequency of recorded observations in the ditch will be determined by the natural variability of conditions and potentially troublesome sections (CAGPL to MVPI, Phase I, pp 16-17).

Under the present construction schedule, Arctic Gas proposes to construct the pipeline in three winter seasons, each season being three to five months long. It proposes to construct a maximum of 450 miles of pipeline in three spreads in one winter season in the discontinuous permafrost area. Thus, an average of some 3.75 miles of pipeline per day is to be inspected by experienced geotechnical inspectors. The problem areas are to be identified and appropriate design changes are to be implemented.

There is a major concern that under the rapid pace of construction, it may be difficult to ensure that all potential

problem areas are detected and adequately dealt with during construction.

There is a concern that, while the mile-by-mile inspection of the ditch will be helpful, in many areas it will not indicate the nature of the soil below the bottom of the ditch. Hence, the presence of frost susceptible material at depth below the ditch may not be identified during construction. Further, it can be difficult for even very experienced personnel to identify the frozen nature of certain soils in a trench wall.

The demand for experienced geotechnical inspectors may be difficult to satisfy.

If, because of the reasons outlined above, the inspection during construction is inadequate, frost susceptible material and areas of high potential differential heave or frozen soils and areas of high potential thaw settlement, may go undetected.

It is apparent that an adequate team of geotechnical personnel with proper experience will be required on site as the work proceeds in order to ensure that potential problem areas are detected and the correct design modifications are implemented. This staff will have to be very efficiently organized and have close working arrangements with the contractors to ensure that design modifications are promptly and correctly expedited. The field inspectors will need to have a clear understanding of the nature of the various geotechnical problems so that they can make the decision regarding the need for design modifications, or the need for further investigation, as appropriate.

RECOMMENDATIONS

16. The Company should demonstrate well in advance of construction how it proposes to cope with the problem (peculiar to this project) of selecting, organizing and administering construction control and inspection personnel.

17. It is recommended that independent review by the proposed geotechnical review board of the field organization for engineering supervision and construction control be undertaken as construction proceeds. This is to ensure that there is a satisfactory mechanism of promptly identifying problem areas and implementing design changes

18. Because of the concerns expressed above it is recommended that pre-construction investigation of the soil conditions along the route should be sufficiently detailed to permit reliable design and minimize reliance upon design changes. item 7). The designers should look to the inspector's logging during construction as a check on previous exploration of soil conditions, not an extension of that exploration.

MONITORING OF FROST HEAVE AFTER CONSTRUCTION

DISCUSSION

The Applicants intend to monitor the pipeline in all areas of frost heave potential. Arctic Gas has also stated that it will monitor all areas of frozen soil which are south of the limit of cold flow and which will, therefore, thaw.

At river crossings Arctic Gas intends to use inclinometers or settlement profilers to measure pipe curvature, while in overland areas it proposes to use risers and other conventional survey techniques. It also intends to visually check the pipeline at regular intervals, and use air photos. Arctic Gas estimates that extensive monitoring would be required over a 400 mile length (NEB 2691-2693). The Applicants recognize the possibilities of a "smart" pig instrumented to read pipe curvature. They have not, however, stated their intention to develop and use such instrumentation. Both Applicants recognize that since most differential heave will normally occur in the initial years of operation, it is during these years that frequent monitoring may be required.

The concerns and uncertainties about frost heave and thaw settlement expressed in the foregoing stress the need for effective monitoring of the performance of the pipe.

The methods for monitoring the pipeline proposed by the Applicant may not permit the frequency of observation that may be required

during the initial year or two of operation. It is possible that some sections of the pipeline would require monitoring monthly.

Visual inspections and surveying risers are not only time-consuming and potentially difficult in winter months, but they may not detect all locations where differential heave is causing significant change in pipe curvature.

If monitoring is not effective or is carried out infrequently, problem areas may develop without detection or with insufficient lead time to plan permanent remedial measures. Thus emergency situations may arise with associated environmental problems.

RECOMMENDATIONS

19. It is recommended that a detailed study of the feasibility of alternative methods and procedures of monitoring the performance of the pipeline be carried out. In particular, the use of an instrumented "smart" pig, which can detect changes in pipe curvature at frequent intervals, appears to be a promising alternative. It is recommended that feasibility studies of the effectiveness of such an instrument for a natural gas pipeline be given high priority.

20. In view of the unprecedented nature and the importance of the monitoring program it is recommended that both the intended procedure and the results of the program be independently reviewed by the proposed geotechnical review board

SOURCES OF INFORMATION

See "Geotechnical Considerations".

PIPE UPLIFT PROBLEMS UNRELATED TO FREEZING

INTRODUCTION

The Applicants have considered two potential causes of pipe uplift which are not related to chilling of the gas: buoyancy; and stresses resulting from thermal expansion of the pipe and high gas pressure.

From Richards Island to the Alberta border, an analysis of Arctic Gas' alignment sheets indicates that a potential buoyancy problem may exist along up to 44% of the route (29:3574-77). In non-permafrost terrain, buoyancy problems may occur in rivers, open bodies of water, muskegs, peat swamps and low-lying flat areas with high water tables. In permafrost terrain, in addition to the above areas, buoyancy problems may occur in beaded streams, thermokarst ponds and ice rich slopes. The three basic conditions under which buoyancy could occur are:

a) open water flotation, e.g. water crossings or wherever free water is encountered in the ditch;

b) delayed flotation following natural flooding of a backfilled ditch, where there is inadequate resistance to uplift; and

c) pipe flotation following melting of permafrost in high ice content silty or oganic soils.

The methods of restraining a buoyant pipe as proposed by Arctic Gas are shown in Table 1 (taken from CAGPL, Application, 8.b.1.3.8).

Arctic Gas has stated (29:3575-76) that, except for open water areas, deep burial of the pipeline will be relied upon as much as possible, and that anchors will only be used for special local circumstances. An NES report (1974a) covers the comparative cost of the various proposed methods of restraining a buoyant pipe. Deeper burial can cost up to $3.50 per pipe foot, mechanical anchors $5 to $10 per pipe foot, and weights $25 to $70 per pipe foot.

The consequences of uplift due to buoyancy are summarised below:

a) Uplift prior to start-up: Interference with construction schedule.

b) Uplift during operation (south of the limit of cooling): Exposure problems; may interrupt surface drainage; could require mobilisation of a substantial work force and a temporary shut down to remedy.

c) Uplift after abandonment: Permanentely interrupts surface drainage with attendant ponding (permafrost) and erosion (siltation) environmental problems; aesthetic impact.

Uplift due to stresses induced in the pipe by temperature changes and the high gas pressure can occur where the pipe bends but is a particular concern at overbends (29:3581). Although a very real problem, the portion of the pipeline likely to be so affected is believed to be considerably less than the portion affected by flotation (29:3580). The consequences of uplift from this cause would be basically similar tc those listed under items (a) and (b) above.

A review of the information available to the Inquiry concerning uplift problems not related to chilling, indicates four areas of concern: design of control measures; design modifications during construction; monitoring and remedial measures; and buoyancy of pipe following abandonment

DESIGN OF CONTROL MEASURES

DISCUSSION

NES has prepared for Arctic Gas an approach to the design of uplift control measures (NES, 1974a). This report considers all available methods for controling uplift of the pipe together with preliminary cost comparisons.

Pipe flotation problems are well known. A portion of the Pointed Mountain Pipeline in muskeg in western Canada floated during the first year after the pipeline was completed. Saddle weights were observed which had slipped off the pipeline (29:3570-71). A recent visit to USSR of a group of Canadian experts (October 1975) observed in northern Russia sections of large diameter pipeline floating with inadequate weights (Canada, Dept. of Industry, Trade and Commerce, 1975).

The problem of re-installing an uplifted or floating pipe is a severe one (see "Monitoring and Remedial Measures") and Arctic

Gas has stated (29:3586, 3589) that in recognition of the problem it has taken a very conservative design approach to avoid the problem.

Figure 4-7 of the NES report (1974a) shows the sensitivity of the design approach in the selection of the design value for the submerged unit weight of the backfill. It is particularly sensitive in the range of 20 to 40 p.c.f., which are typical values for the backfill soils which would cause concern. For backfill soils in this range, the size and integrity of the backfill mound is critical. The problem of erosion of the mounds and slumping of ice-rich backfill has been discussed (CAGPL, Prepared testimony, p. 14).

In view of the above, the selection of a low safety factor of 1.25 (NES, 1974a, Section 4.1.3) is inappropriate.

It is also apparent that some backfill conditions will, in thaw, resemble and behave as a thick slurry. This potential condition in the frozen state may well go unrecognised. The NES report (1974a) is not applicable to this condition -- its application would lead to a result on the unsafe side.

It is considered that the potential for pipe flotation could be severe south of the limit of cooling, depending on the final location of this limit. Neither Applicant has investigated this aspect in detail. The NES report (1974a) is mainly concerned with the potential for uplift prior to start up, north of the limit of cooling.

Although uplift and exposure of the pipeline can pose unacceptable engineering problems, in some areas (towards the south) it may be possible to tolerate an uplift condition from the engineering standpoint. In view of the problems of reinstalling an uplifted pipe, any environmentally undesirable aspects of the condition may go unattended for a lengthy period of time.

The design of field pipe bends is concerned with unprecedented gas pressures and thermal conditions in a large diameter pipe. Faulty pipe bends, if not identified during pressure testing, will likely become evident immediately upon start up. The risk of problems developing from this source should rapidly diminish from start up.

Since Arctic Gas is predominantly depending on burial for controlling overland buoyancy problems, a design approach vulnerable to a change in field conditions may result in frequent pipe flotations in potential buoyancy areas where soil conditions may only moderately differ from those assumed during design.

Pipe flotation would normally develop during thaw seasons. Thus if emergency repairs became necessary, they would have to be carried out during an environmentally sensitive period.

Other consequences of uplift due to both buoyancy and stress build-up have been outlined earlier in the Introduction to this section.

The significance of this concern is essentially similar for both Applicants. However the flotation problem is more readily solved by Foothills because of its proposed use of a smaller (42 inch) diameter pipe resulting in a smaller buoyant uplift force. Foothills also proposes to use a lower gas pressure which would reduce the problem of possible uplift at pipe bends. On the other hand Foothills has indicated a limit of chilling appreciably further north than that indicated by Arctic Gas, and thus has greater exposure to buoyancy problems resulting from melted permafrost.

RECOMMENDATIONS

1. The Company should undertake detailed drilling and route investigation to identify the location of those areas requiring design of uplift control measures, and to determine the most suitable design.

2. Uplift due to buoyancy is an important factor to be taken into account in selecting the southern limit of chilling.

3. Greater emphasis should be placed on the depth of pipe burial in areas subject to uplift by buoyancy. The cost-benefit approach initiated by Arctic Gas (NES, 1974a) should be expanded to allow for the costs of design uncertainties, possible affects on schedules, maintenance costs etc.

4. A conservative procedure should be maintained throughout. The most appropriate approach in design of buoyancy controls and pipe bends is to use a suitably high factor of safety.

The Company should consider the use of a varying factor of safety depending upon the reliability and detail of site information, and the local consequences of uplift or buoyancy.

DESIGN MODIFICATION DURING CONSTRUCTION

DISCUSSION

The selection and design of buoyancy control measures is dependent upon site conditions. Decisions will be made well ahead of construction regarding the measures that will be used along the route where there may be potential buoyancy problems. For example, Arctic Gas has already decided to use continuous wire reinforced concrete jacket for the twin 36 inch lines across the Delta as well as for river crossings (NEB, 2044;45).

Notwithstanding the additional subsurface investigations to be carried out along the route prior to detailed design, it is reasonable to expect that during construction additional areas of potential buoyancy problems, not identified during the design stage, will be encountered. In addition, sections may be encountered during construction where the soil conditions are considerably more severe from the buoyancy standpoint than initially predicted during design. Under the proposed construction schedule, such areas would have to be identified by the Company's field inspectors and appropriate design changes implemented.

Arctic Gas also proposes to pressure test the pipe during construction, to a value in excess of the operating gas pressure (29:3586).

There is a concern that under the rapid pace of construction it will be difficult to ensure that all potential areas of pipe buoyancy, not identified during design, are recognized during construction and the necessary design changes implemented.

There is concern that, because of the demand for experienced geotechnical inspectors imposed by this project, these inspectors may not be sufficiently experienced to detect (under winter conditions) significant changes in site conditions which would affect pipe buoyancy and pipe bend design.

The consequences of not recognizing and dealing with additional potential areas of pipe uplift, or the need for changes in the design of control measures, could be pipe uplift at an unknown number of locations both during and after construction. The consequences of pipe uplift were outlined above.

RECOMMENDATIONS

5. Since it is highly desirable to limit the possibilities of pipe uplift, the Company should examine the difficulties associated with the field checking and inspection from the standpoint of buoyancy control and should demonstrate how it intends to overcome these difficulties; such plans should be prepared and submitted to the Agency at final design. There is a need, for example, to establish local guidelines to assist the inspectors in recognising and evaluating under winter conditions, site facts which are conducive to pipe uplift.

6. It is recommended that independent review by the proposed geotechnical review board of the field organization for engineering supervision and construction control be undertaken as construction proceeds. This is to ensure that there is a satisfactory mechanism of promply identifying problem areas and implementing design changes.

7. Because of the concerns expressed above it is recommended that pre-construction investigation of the soil conditions along the route should be sufficiently detailed to permit reliable design and <u>minimize</u> <u>reliance</u> upon design changes. The designers should look to the inspector's logging during construction as a check on previous exploration of soil conditions, not an extension of that exploration.

<u>MONITORING AND REMEDIAL MEASURES</u>

DISCUSSION

Even with the most conservative design approach and effective field control, it is possible that areas with potential buoyancy problems will not be treated during construction. Significant changes can also occur during operation, such as erosion and slumping of the backfill mound, and melting of permafrost south

of the limits of chilling, which could result in buoyancy problems. It is expected that most problems will become evident during the initial years of operation. The Applicants therefore propose to include an inspection of all aspects related to buoyancy in their monitoring program. Arctic Gas has indicated in evidence before the Inquiry that the problems associated with effecting remedial measures are severe (29:3572, 3586, 3589). The remedial measures may well involve shutting down the system and replacing a segment of pipe (29:3588).

The methods for monitoring the pipeline proposed by the Applicant may not permit the frequency of observation that may be required during the initial year or two of operation. It is possible that some sections of the pipeline would require monitoring monthly.

Other than to comment on the severity of the problems involved, Arctic Gas has not discussed or considered in detail any remedial measures, but has in fact stated: "We are not counting on a remedial measure to accommodate that particular situation in any instance" (29:3586).

It is apparent that if the monitoring procedure is not effective then potential problem areas will not be identified until pipe flotation occurs.

Since suitable remedial measures have not been planned in detail, there is no way of assessing the effectiveness of the measures and any impact they will have on the social and environmental scene.

RECOMMENDATIONS

8. In view of the unprecedented nature and the importance of the monitoring program it is recommended that both the intended procedure and the results of the program be independently reviewed by the proposed geotechnical review board.

9. The Company should conduct a detailed study of the potential problems resulting from an uplifted or floating pipe, the feasibility of various remedial measures, and the impact of these measures.

<u>BUOYANCY OF PIPE FOLLOWING ABANDONMENT</u>

DISCUSSION

The Applicants propose to leave the pipe in the ground following abandonment. They have suggested that some portions of the pipe, which may become buoyant with time or because of changed conditions during the operating life of the project, be filled with water.

Although the Applicants have investigated buoyancy problems prior to startup, very little emphasis has been placed on possible buoyancy problems that may be encountered after the pipe is abandoned and chilling ceases. The suggestion to flood the line is a concept which has not been studied in detail. This concern affects most of that portion of the line south from Fort Good Hope to the limit of chilling.

Buoyancy problems developing after abandonment have in one sense the greatest potential for adverse impact, since it has not yet been decided who would be responsible for any remedial actions. Without decisions and agreements in this area, any problems may will go unattended.

RECOMMENDATIONS

10. The possibility of pipe flotation after abandonment should be investigated and provided for in the Company's design.

11. An agreement is required on who will be responsible for any necessary remedial actions after abandonment and how these actions will be funded.

SOURCES OF INFORMATION

See "Geotechnical Considerations".

Table 1

METHODS OF RESTRAINING A BUOYANT PIPE

Methods	Open water		Natural flooding of backfilled ditch		Melting of permafrost
	Permafrost	Non-permafrost	Permafrost	Non-permafrost	
Concrete jacket	x	x			
River weights (bolted)	x	x			
Saddle weights	x	x	x	x	x
Deeper burial			x	x	x
Controlled flooding			x (Northern parts only)		
Frost anchors			x		
Pipe anchors			x	x	

From: CAGPL, Application,
Section 8.b.1.3.8

SLOPE STABILITY

INTRODUCTION

Although landslides in permafrost soils have been classified in various ways they can be basically subdivided into shallow failures involving thawed soils and deep seated failures involving frozen and thawed soils.

Typical of shallow failures are skin flows which involve movement of the active layer over the top of the permafrost. Skin flows occur in many of the terrain types along the pipeline routes (CAGPL, Responses to NEB, Vol. V, letter 4, Q.8, p.3) and can readily be caused by minor disturbance such as clearing of the right-of-way. They may also occur in the backfill placed above buried pipe in sloping ground. Arctic Gas has stated: "While this type of landslide cannot immediately threaten the integrity of the pipeline, it has been studied in considerable detail because, if left unchecked, unsafe conditions may develop after several thaw seasons" (NES, 1974b, p.3).

Deep seated slides involve displacement of a large mass in the form of blocks of relatively intact material. In the Mackenzie Valley it is reported that these slides have affected slopes in the range of 100 to 260 feet high with an overall slope angle after failure of 9.5° to 20° (NES, 1974b, 4.3-1, 4.3-2). A large slope failure developing upon the right-of-way would likely result in pipeline breakage.

Based on field reconnaissance and experience, Arctic Gas indicates that permafrost slopes flatter than 3° are stable under natural and disturbed conditions. It reports that between Prudhoe Bay and Alberta "a total of about 686 slopes have been classified as being potentially unstable based on the Applicant's terrain classification studies (NES, 1974b, p.1). Of these some 344 are less than 6° in slope and less than 40 feet in height. The 686 slopes catalogued represent a total length of about 37 miles within a total mileage of 1450 miles of pipeline right-of-way north of the 60° latitude so that slope stability considerations are necessary over only a relatively small (2-6%) cf the route. Moreover, while many of these slopes have been classified as being potentially unstable on the basis of slope angle measured photogrammetrically and terrain typing, closer examination suggests that many are, in fact, stable".

Frost creep constitutes another form of slope movement not normally categorised as failure. It involves downhill movement of relatively intact material at low annual rates.

A review of the information available to the Inquiry with regard to slope stability relative to the proposed gas pipeline, indicates four areas of concern

a. Prediction of flow slide and bi-modal flow activity or backfill instability.

b. Behaviour of deep seated landslides.

c. Effect of interference of subsurface drainage.

d. Creep of ice-rich slopes.

These concerns are discussed in the following sections.

FLOW SLIDE AND BI-MODAL FLOW ACTIVITY OR BACKFILL INSTABILITY

DISCUSSION

Arctic Gas has indicated that "skin flows can occur for a wide variety of reasons but recent research has stressed the dominant influence of thawing in promoting instability" (CAGPL, Responses to NEB, Vol. V, letter 4, Q.8, p.4). The Applicant has accordingly developed a method of analysis based upon the theory of thaw-consolidation. This theory is concerned with the development of excess water pressure in the pores of a thawing soil. In particular it considers the rate at which water is produced by thaw versus the rate at which water can be squeezed out of the thawed soil. Excess pore water pressures can result in slope failures and for the purpose of analysis a slope stability equation has been developed to permit computation of the factor of safety against sliding (McRoberts et al., 1974b).

> "Bi-modal flows are a form of landslide that must first be initiated by another mass movement process. That is, they do not start of themselves ... skin flows appear to be the most active natural process which initiate bi-modal flows ... Because this type of landslide can be relatively deep seated it might

> possibly threaten the integrity of the buried pipeline. The Proposed route has carefully avoided all known landslides and there are no known bi-modal flows within considerable distances of the pipeline. However, new flows may be initiated by natural phenomenon outside the right-of-way ... the rate of movement of the headscarp of a bi-modal flow ... may be considerable but there will be ample time to devise stabilization techniques for bi-modal flows which develop outside of the right-of-way and threaten the integrity of the pipeline" (NES, 1974b pp.37-39).

Although the thaw-consolidation theory is supported by valid reasoning and laboratory research, there is only one well-documented case history (Morgenstern et al, 1974a). The authors of this reference conclude: "Clearly many more well-documented case histories are required for differing soil and thermal conditions to increase the level of confidence in the application of the theory".

Further, although the application of the thaw-consolidation theory in the slope stability equation results in a reasonable mechanistic model of this phenomenon, there are no published well-documented case histories to confirm the validity and pratical application of the equation.

It has been argued by Foothills (65:9588-92) that the natural variability of the parameters required in the thaw-consolidation theory can be so great as to render the theory unreliable and of doubtful practical value in these circumstances (MVPI, Summaries, No.32, p.3). Similar criticism has been voiced by others appearing before the Inquiry (Carleton Univ., 1975 p. 62). Foothills has placed emphasis on field observation and measurement of actual pore pressures, but has not carried out sufficient field work to demonstrate the praticability of this approach.

Although Arctic Gas recognises that there are other mechanisms controlling skin flows, it has not evaluated them in the same degree of detail (Carleton Univ., 1975, p. 58).

Skin flows will likely be the most common form of slope instability occurring along the pipeline right-of-way. The Applicants have stated that the direct geotechnical and environmental implications of skin flow failures are not severe (NES, 1974b, p.7). However, if these failures occur to a greater degree than anticipated and/or if they are left untreated, larger slope failures including bi-modal flows may result, or significant surface run-off erosion could develop.

The slope stability equation and the theory it depends on will be used to indentify all potential areas of flow slide or backfill instability. Furthermore, the design of the proposed stabilization measures utilizes this same basic equation. If this equation does not correctly predict actual field behaviour, and if it is inaccurate on the unsafe side, numerous areas of instability may unexpectedly develop.

RECOMMENDATIONS

1. In selecting the route alignment and any necessary changes thereto the Company should be conscious of avoiding to the maximum extent practicable areas of questionable slope stability. The Applicant should be required to demonstrate that he has undertaken field surveys of the route in sufficient detail to ensure that all significantly unstable areas along and adjacent to the route have been detected prior to commencing construction.

2. The Company should undertake detailed field investigation and study of a number of flow slides selected to consider the effect of variation in topography, slide geometry, soil type and cause. The purpose of this work is to clarify and extend understanding of flow slide mechanisms in relation to the installation and maintenance of the proposed pipeline.

3. It is recommended that all feasible preventive and remedial measures be given thorough technical and economic consideration.

4. Notwithstanding Recommendation 1, it is unlikely, should the pipeline proceed according to schedule, that the level of confidence in predicting and analysing flow slides attained by the start of construction will eliminate the concern expressed in this section. The work covered under

Recommendation 1 will however, serve to mitigate some of the concerns.

The Company should therefore develop a plan for reliably detecting the occurrence of flow slides and the threat of bi-model flows along and adjacent to the pipeline right-of-way. Monitoring should be carried out by geologists or geotechnical engineers experienced in the investigation and assessment of slope stability hazards in permafrost terrain. To ensure the prompt construction of suitable stability measures, it is expected that this will involve stockpiling of materials along the route.

Stabilization should be carried out with a minimum of disturbance in a failure area as such an area is likely prone to further failures if the natural cover is disturbed. This clearly requires that carefully planned procedures be devised or the cost of stabilising one location may be the initiation of another or several other flow slides. It also follows that particular care and refined construction techniques should be used during initial construction through known flow slide areas.

5. In view of the concerns expressed above any stabilising measures should be conservatively designed to eliminate the need for any further remedial action in the area.

THE BEHAVIOUR OF DEEP SEATED LANDSLIDES

DISCUSSION

The pipeline route crosses a number of relatively steep high slopes, usually at river crossings, where there is a possibility that a large, deep seated failure may occur. Arctic Gas has identified 33 slopes higher than 100 feet with slope angles greater than 9°. It believes that fewer than this number are susceptible to deep seated failure because of the absence of other factors which it implies are necessary in failure.

The stability of these slopes is assessed using the same basic geotechnical techniques and principles which are used in non-permafrost areas. Some modifications to these principles are required where the ground is completely or partially frozen (Responses, Appendix B, pp. 45-47).

There are a number of aspects concerning deep seated landslides in permafrost areas which are not well understood, and for which the behaviour is apparently unique to frozen ground. In particular, the magnitude of available strength along potential failure surfaces within frozen ground and the role of potentially high pore pressures at the permafrost base are uncertain.

There are no well documented case histories. The only published analysis of such a slide is based on circumstantial evidence on the soil and thermal condition of the materials actually involved in the slide, a lack of topographic data, and no pore pressure measurement. "Geomorphological evidence and experience during drilling at a slide on the Mountain River suggest that substantial pore pressures exist within the unfrozen materials beneath the permafrost. Unfortunately attempts to measure these pore pressures have not been successful and data obtained in the future will be of considerable value in this regard" (McRoberts, et al., p.572).

Although the preliminary studies conducted by Arctic Gas and its consultants indicate that the deep seated failure mode can be successfully analysed using the indicated approach, definite conclusions on the reliability of the approach cannot be drawn until more field evidence is obtained.

If a critical condition is overlooked, either as a result of inadequate field data or because of an incomplete understanding of the failure mechanism, the ensuing large landslide would lead to engineering and environmental problems. A large landslide could occur rapidly without apparent warning, and thus could result in emergency repairs with their attendant environmental damage.

RECOMMENDATIONS

6. The Company should investigate and analyse in detail every slope along the right-of-way which possesses a potential for deep-seated instability. Such slopes should be selected for analysis so as to ensure that no critical areas have been overlooked.

7. Because of the lack of detailed knowledge of slides involving frozen material, geotechnical investigations undertaken to assess the stability of the higher slopes along the route

should be more intensive than is normally considered adequate for similar situations in non-permafrost areas.

8. Because of the lack of precedent in analysing steep high slopes involving frozen materials, any protective or remedial measures such as berming should be more conservatively designed than is normal for non-permafrost areas.

9. A detailed annual inspection of all pertinent slopes must be included in the post-construction monitoring program. The Company should make liberal use of proven types of slope instrumentation to assist monitoring.

EFFECT OF INTERFERENCE OF SUBSURFACE DRAINAGE

DISCUSSION

Where the chilled pipeline traverses slopes in non-permafrost areas, the frost bulb will disrupt the natural subsurface flow of water (CAGPL, Responses to NEB, Vol. IV, letter 4, Q.4, p.6). It is conceivable that under some conditions, especially where the pipeline is on a cross slope, the presence of the frost bulb could result in a significant increase in water pressures upslope from the pipeline.

The possibility of slope failures, as a result of this cause, has not been given adequate consideration by the Applicants. This condition may aggravate marginally stable slopes. Any resulting slide will tend to occur unexpectedly. The slide may be large enough to cause some distress to the pipe. Emergency measures may be required with their attendant environmental problems.

RECOMMENDATIONS

10. The Company should design and test the feasibility of methods for relieving subsurface water pressures on the uphill side of the frost bulb.

11. During construction, geotechnical field personnel should be made aware of this potential hazard. Observations of significant subsurface seepage should be reported and protective measures implemented as required.

CREEP OF ICE RICH SLOPES

DISCUSSION

Initial theoretical studies indicate that under some circumstances, ice rich slopes in permafrost can creep a significant amount over a number of years. There is little field evidence to indicate whether such theoretical predictions actually take place in the field (McRoberts, 1975).

Arctic Gas is of the opinion that creep would likely not be a significant factor affecting the pipeline. It has however proposed a number of methods of overcoming the problem if it occurs (CAGPL Application, p.53; MVPI, Summaries, Sec A-10; NES, 1974d, p.51).

In 1975, Arctic Gas initiated a testing program to determine the creep properties of a range of frozen soils. Previous studies by others were reportedly carried out at higher stress levels than are applicable to the pipeline. The purpose of the program is to provide data for "less conservative final design" (CAGPL, Prepared Testimony to NEB, Geotechnical Panel).

The Applicants have not stated how they would identify areas where significant creep is anticipated. In view of the lack of field information available regarding creep behaviour of ice rich slopes it is unlikely that any reliable method exists at this time. Although Arctic Gas has recognized the need for designs to combat slope creep, it has to date discussed concepts only. There are no specific data to indicate the effectiveness of these concepts.

The available evidence indicates that the creep of ice rich slopes would most likely be of significance on the steeper slopes, in which relatively high ice contents are present (McRoberts, 1975). It can be expected, therefore, that creep would be an important consideration at a limited number of locations. At these locations, however, the pipeline could be broken if large creep movements take place.

It is recognized that creep movements, if they do occur, would most likely proceed at a relatively slow rate (McRoberts, 1975). It is likely, therefore, that through use of suitable field instrumentation, such movements could be detected at any early

stage and suitable remedial measures could be implemented before the pipeline is affected.

RECOMMENDATIONS

12. Arctic Gas indicates that further study into the phenomenon of creep of ice rich slopes is presently underway. It is recommended that this work continue to the point where sufficient information is obtained to enable a confident engineering prediction to be made as to which slopes have a potential for significant creep movements.

13. The Company should instrument slopes which appear to have a potential for creep movement, so that movements will be detected at an early stage. The development and use of an instrumented "smart" pig would also be a valuable supplement.

SOURCES OF INFORMATION

See "Geotechnical Considerations".

DRAINAGE AND EROSION CONTROL

GENERAL RECOMMENDATIONS

The Company shall take appropriate mitigative measures and install sufficient control devices to effectively prevent disruption of the natural surface and shallow subsurface drainage and the ensuing problems of ponding, erosion, the deposition of sediment on land or its discharge into waterbodies.

The responsibilities of the Company, in this regard, shall extend to all lands and waterbodies used by the Company at any time during the construction, operation and maintenance of the pipeline and its associated facilities, to adjacent areas disturbed or damaged as a result of developments on lands under the care of the Company, and to adjacent areas where disturbances may affect lands under the care of the Company.

DISCUSSION

Several aspects of the construction, operation and maintenance of the pipeline and related facilities have a potential for causing disruption of the surface and shallow subsurface drainage, initiating or accelerating thermal or mechanical erosion, and initiating or accelerating the deposition of sediment on the ground surface or its discharge into waterbodies. This potential for drainage disruption and enhanced soil erosion and sedimentation cannot be eliminated if the project is to go ahead. Hence, the objective of the terms and conditions must be to reduce the range and impacts to a level where protection is considered adequate.

While general methods of control can be suggested, the direct impacts of drainage disruption or enhanced soil erosion and sedimentation are site-specific. Secondary impacts may be site-specific or more wide spread. Ideally the terms and conditions governing the selection and construction of control measures should also be site-specific. However such an approach is not feasible, as the most effective methods can only be selected and

designed on the basis of detailed field data. Such information is not available at this time, and much of it will only become available as construction proceeds. Sufficiently detailed site information is not likely to be available at the time of final design.

Even the more general recommendations cannot be as location-specific as would be desirable, because neither Applicant has sufficiently finalized the pipeline location or the location of ancillary facilities. Such final locations will depend in part on the results of geotechnical and other site investigations and on the terms and conditions included in the land use documents.

Recent construction experience in the Mackenzie Valley which is analagous to the construction of a pipeline and its ancillary facilities is exemplified by the design and construction of roads, particularly the Mackenzie Highway, airfields and settlements. In the design and construction of the Mackenzie Highway northwest of Fort Simpson and around Inuvik great effort has been made to mitigate the disruption of drainage and soil erosion. This has been done by using an overlay form of structure as far as the topography permitted, the provision of numerous through-grade culverts for the passage of overland flow, no unnecessary ditch excavation, the use of ditch blocks to prevent water flowing parallel to the road berm, the use of non-erosive blankets and ditch checks to prevent erosion, and other techniques. In particular, the operation of any vehicles off prepared, gravelled surfaces is strictly controlled, and is kept to an absolute minimum. Similar approaches are used in construction in and around settlements, including wharves and air fields.

There are no fundamental differences between the proposals of the two Applicants in terms of the measures they contemplate using to control drainage and soil erosion. However, there is a significant difference in the potential for drainage disturbance and soil erosion.

Arctic Gas is proposing to use two different methods of pipeline construction -- arctic construction and conventional construction. Conventional pipeline construction involves clearing the land with machines and grading the ground surface to provide a smooth roadway for the transportation and work equipment. This method will be the dominant method south of about 65°N; it will also be used further north where the terrain

and permafrost conditions permit. The arctic construction method involves hand clearing of vegetation in areas of sensitive terrain and the construction of snow roads for the equipment, with no cutting or mechanical damage to the surface vegetation mat. This method will be the dominant method north of about 65°N, and will be used whenever necessary further south.

Foothills, on the other hand, only refer to one method of construction in both its Application and evidence. This is essentially what Arctic Gas have called conventional. The impression given by Foothills' Application and evidence is that it would rely almost entirely on this approach, with cut-grading of the ground surface. The only exceptions to this are a statement by Mirosh that there would be no grading of sidehills in areas of sensitive permafrost (67:9844-55), and the recent announcement that Foothills is now proposing to build the northernmost 50 miles of pipeline in autumn, off a gravel work pad. The extent to which this method would require cut-grading is not known. It is expected that the more extensive use of cut-grading in right-of-way preparation proposed by Foothills will lead to more extensive problems of surface stability, drainage disruption and enhanced soil erosion.

Both Applicants regard the establishment of a continuous cover of new vegetation across the right-of-way and other disturbed areas as the best long-term protection against erosion and sedimentation. However, it may be some years before the vegetation cover is thick enough and continuous enough to provide sufficient protection to the ground surface. The problem is particularly acute along the ditchline, as the backfill material will not be well consolidated and so will be very susceptible to erosion. Any erosion will be caused by surface flows of water resulting from the spring runoff of snow-melt water and runoff from summer rainstorms. This water, flowing overland, has to be passed across or along the right-of-way, depending on the orientation of the right-of-way relative to the natural ground slope, without allowing it to build up to a damaging volume or velocity. The approach contemplated is to guide surface water across the right-of-way with low diversion dikes; breaks will be provided in the backfill mound and various devices will be used to check the water velocity. In addition, various surface treatments will be applied to the sides of the diversion dikes and the backfill mound and to the floors of the mound breaks to further inhibit erosion. The treatments contemplated include the use of non-erodible granular materials, gabion blankets, fibre

mats clay bentonite or other sealants. The various sealants that may be used must be justified in terms of their potential for pollution and toxic effects. On the downstream side of the mound breaks, these will be supplemented with baffles and diverters to break up and disperse any concentrated flow of water before allowing it to drain onto the undisturbed land beyond the right-of-way edge.

The various surface treatments proposed are all more or less standard practice, particularly in highway engineering, and they can be expected to work quite well if they are conscientiously applied in the right places. There is, however, some concern over the spacing criteria for the mound breaks and the probable efficacy of the flow dispersing structures. Mound breaks are to be located wherever a defined drainageway crosses the right-of-way. However, in some areas, surface run-off occurs as a dispersed overland flow, and here it is essential that mound-breaks be frequent enough to not unduly concentrate the drainage. The best approach to this is a) a walk-over of the right-of-way the summer before construction commences to mark all drainage ways, however ephemeral, and b) a rational design for the spacing of mound breaks in the areas between these drainage-ways. The rational design should be based on the concept of a "standard project flood", as described in "Crossings: Design Flows and Levels".

In some areas, one of the main problems in the designing and maintaining of the mound breaks and other drainage control structures will be the effects of the frost bulb. As the pipe heaves due to the build-up of ice in the ground, the mound breaks will become less effective, and a major maintenance effort will be required each year to adjust the threshold of the mound breaks to keep them working properly. A related problem will be the effect the frost bulb has on shallow sub-surface drainage. To the extent that the frost bulb constricts the active layer or any near surface aquifer and so interrupts flow, the water will back-up above the pipeline and seep out onto the ground surface. If this occurs in summer, it will increase the amount of surface flow -- an effect that has to be included in the calculations of the size and spacing of mound breaks. If this seepage occurs in autumn or winter, the seepage water will freeze, giving rise to surface icings along the side of the frost bulb.

Surface icings, in themselves, will create further problems by changing the flow of spring run-off. They could so change the

whole pattern of drainage on slopes during run-off that the structures built to control drainage and prevent erosion may fail to work. Due allowance for this possibility must be made in the selection and design of control structures. Furthermore, water flowing across ice can build up higher velocities than water flowing across vegetation or soil at the same slope angle. When this fast-flowing water leaves the ice surface and moves onto soil, its erosive power is considerably increased.

Any pipeline across the northern part of the Mackenzie Delta will be subject to flooding, caused by either storm surges or by ice jams during break-up. This risk of flooding applies to the Arctic Gas cross-Delta segment between about MP 320 and MP 372 and to the mainline routes of both Applicants between Niglintgak and Taglu, from Taglu to about MP 17 (Arctic Gas) or MP 8 (Foothills) and at the crossings of East Channel. All above ground structures, including all drainage and erosion control structures, in this area have to be designed and built in such a way as to resist the damaging effects of waves and ice jams. This will mean more extensive use of gravel and cobbles for the construction of the backfill mound and diversion dikes. Structures in more exposed locations may have to be protected by riprap. More frequent mound breaks may be required, and they may have to be designed for reversals in the direction of water flow.

Different approaches to drainage and erosion control and the maintenance of surface stability may be required along different sections of the right-of-way, depending on the mode of construction used and the degree of disturbance of the ground. Areas where "arctic construction techniques" have been used will present less of a problem than in areas of "conventional winter construction", in that a smaller amount of ground has been disturbed -- only the ditch line in the former case, as opposed to most of the right-of-way in the latter. However, the consequences of erosion and the difficulty of stopping it once started may be much greater in the areas of "arctic construction". In general, both Applicants propose to apply similar remedial measures to all areas, regardless of the mode of construction used. It may well be that the specific site conditions of slope, soil material and area drained exert more influence on the selection and placement of control structures.

This will be particularly so in sections where the right-of-way has been cut down at the approaches to river crossings. Some quite substantial cuts will be required in some locations,

resulting in wide zones of disturbance. Harlan and Williams (CAG) stated that all such cuts would be filled in, presumably up to the original ground elevation (39:5151-53). Nonetheless, special attention will have to be paid to the control of drainage, the prevention of erosion and the trapping of sediment on all slopes, valley sides and stream banks.

In addition, special approaches will also be required in three other areas. These are:

a) within the Mackenzie Delta,

b) sections of pipeline along which a surcharge berm is built to control frost heave, and

c) sections of pipeline constructed in summer or autumn of a gravel work pad.

A surcharge berm is presently proposed in the southern part of the Northwest Territories to limit the extent and amount of frost heave around the cold pipeline. It will be a more or less continuous ridge of borrow material with a broad, flat top, side slopes between 1:1 and 1:2 and will be vegetated. Breaks will be left in the berm for streams and rivers, and additional breaks will be left to provide for surface drainage. Construction of the berm will normally be coupled with deeper burial of the pipeline, as a total approach to frost heave control. It is conceivable that, in order to maintain continuity in shut-off loading across certain water courses, the Company will choose to not have breaks in the surcharge berm, but rather to install culverts. The height and width of the berm are not known at this time. In statements before the National Energy Board, witnesses for Arctic Gas stated that it would be three to eight or ten feet high and 25 to 65 feet wide. They agreed that if their estimates of the rate and amount of frost heave were in error, the size of the berm may have to be increased, but in any event, the final height would never be as much as 20 feet (equivalent to 100 to 120 feet wide). The recent announcement by Arctic Gas (7 October 76) of instrumental problems in its frost heave susceptibility analyses of soils from the Mackenzie Valley, means that these earlier estimates of the height and width of the surcharge berm are tentative at best.

The various measures proposed by the Applicants to control drainage and erosion across and along the right-of-way are all

designed for areas where there is no surcharge berm. What modifications will be necessary to accommodate a surcharge berm are not known. As the surcharge berm is designed only to control frost heave and keep it within reasonable limits, rather than to prevent it altogether, the most severe problem is likely to be maintaining drainage through the berm breaks. Coupled with this will be the problem of preventing water from flowing alongside the berm and eroding it and the right-of-way.

Similar problems are presented by Foothills' recent proposal to construct the northern-most 50 miles of the main line in autumn off a gravel work pad. The proposal has a very high potential for disruption of drainage, erosion and sedimentation, and with little possible in the way of mitigative measures.

One matter which has to be considered in the design and construction of drainage and erosion control structures is the need for travel along the right-of-way. Routine travel for purposes of inspection, maintenance and repair will be done, as far as possible, in winter but in an emergency, summer travel along the right-of-way with vehicles will be permitted. Any vehicle movements along the right-of-way will tend to damage the diversion dikes or backfill mound, particularly in summer when the ground surface is not frozen, unless provision has been made for it. The repair of such damage may call for more travel on the right-of-way leading to further terrain damage. This problem can largely be prevented by designing and constructing the diversion dikes and other structures so as to facilitate and withstand the passage of vehicular traffic.

There are two main concerns with regard to the construction of gravel pads for compressor stations, stockpile sites, airfields etc. These are a) the disruption of surface and shallow subsurface drainage and b) the sediment content of water drainage off the pads.

Surface and subsurface drainage will be more or less disturbed by the construction of any large gravel pad. This will first show as ponds of water developing alongside the pad. As these ponds drain along the edge of the pad, erosion will begin. Thermokarst or thermal erosion will also develop if the ground has a significant ice content. Provision of culverts under pads (particularly airfields), ditches around pads, check dams and other devices to prevent erosion will be necessary.

Drainage water from pads may contain considerable quantities of fine sediment, and this must be prevented from reaching any waterbodies. If there is any risk of this run-off water containing toxic chemicals, such as fuel or other petroleum products, the procedures recommended in "Spill Prevention and Control" should be followed.

Permanent gravel roads present similar problems of drainage disruption and run-off, and similar responses are appropriate. Flows of water in ditches alongside the road should be kept to a minimum by the use of through-grade culverts. In areas of sensitive terrain, no roadside ditches should be cut. The permanent project roads will not be heavily used, but they may be used by heavily laden vehicles. In such a case, the use of "low-water crossings" is not appropriate. Snow roads present their own problems of disruption of drainage which are specifically dealt with in "Snow Roads".

Apart from continued maintenance, the drainage and erosion control structures should be carefully observed each year as part of the line patrol procedure. In locations where the structures need excessive maintenance or else periodically fail completely, they should not be rebuilt repeatedly to the original design. Instead new structures should be designed and installed, structures which are designed to overcome or avoid the problems of the original designs, and which will still perform the original function of controlling or preventing erosion.

The pipeline operator has a responsibility to construct and maintain devices to control drainage and prevent erosion on all lands disturbed during the construction of the pipeline. This includes both lands under lease by the Company and lands not under lease, such as borrow sites or stockpiles. In some cases, the Company's responsibilities may extend to lands adjacent to the land under its care, even though never actually disturbed directly during construction or operation.

It is apparent, from the discussion in the preceding paragraphs, that the selection and design of drainage and erosion control measures is a complex matter. It cannot be done until late in the construction process, when the details of site, soil, slope and schedule are known. This will cause some difficulties in final design for the Agency and the Company.

RECOMMENDATIONS

1. The Company's drainage and erosion control designs, site plans, and construction plans shall be subject to approval by the Agency, both at the final design stage and just prior to installation. The installations shall be subject to inspection and approval by the Agency prior to the spring thaw period following their construction and at subsequent times. The following recommendations are for guidance of both the Company and the Agency.

2. Separate approaches are required for drainage and erosion control along the pipeline right-of-way and at all other sites including pads, roads, airfields etc.

3. Site-specific drainage and erosion control plans shall react to local, site-specific environmental or land-use concerns and not only to estimates of erosion probability or potential drainage disruption. For example: where erosion from any land proposed for use by the project has a potential for direct damage to fish or aquatic wildlife, devices for catchment, settlement, and/or diversion shall be provided and sites shall be adjusted, where appropriate, to permit catchment between the slope and any waterbody or wetland.

4. Potential for erosion and hence need for control measures can be reduced by selection of sites with minimum slope and by minimizing disturbance of the ground surface during clearing and construction: these measures are particularly important in areas of sensitive permafrost and fine grained soils. These approaches shall be reflected in final design locations and in final construction plans.

5. Drainage and erosion control structures are intended to complement the stabilizing effect of revegetation: nonetheless, they must be designed so as to achieve the required control unaided by vegetation. The structures shall be kept in repair and cleared out until their function has been completely taken over by new vegetation.

6. Structures which fail repeatedly or which present excessive and continual maintenance problems shall be redesigned and reconstructed so as to be both effective and more stable.

7. Erosion control structures shall be emplaced prior to the first spring following commencement of construction, whether construction has been completed or not. At sensitive sloping sites, clearing is considered to be part of construction in this context.

8. Any failures in any structures or devices shall be promptly repaired and damaged lands shall be restored as near as possible to the original condition.

9. Drainage and erosion control devices shall be designed and constructed in a manner that will facilitate travel along the pipeline right-of-way and without the devices being rendered ineffective by the passage of vehicles.

10. Any chemical or petroleum based sealants, sprays or soil stabilizers proposed for use shall be tested for toxicity and potential for pollution. Specific approval shall be obtained for each material proposed to be used.

11. All drainage ways and control structures shall be designed and maintained in a manner that will accommodate or allow for changes in ground level along the pipeline right-of-way, caused by frost heave, the growth of the frost bulb or thawing of the ground and surface subsidence.

12. Allowance shall be made in the design and maintenance of drainage controls for disruption of drainage patterns due to the growth of stream icings and surface icings alongside the right-of-way.

13. Drainage breaks shall be provided into the backfill mound, surcharge berm or gravel work pad at all watercourse crossings, at all places where ephemeral flows of surface water cross the pipeline, and at frequent intervals in between to allow for the overland flow of spring melt or summer storm run-off. The spacing of such breaks shall be determined by a rational approach based on the concept of the "standard project-flood" described in "Crossings: Design Flows and Levels".

14. In the selection, design and construction of drainage and erosion control devices on the right-of-way, the following objectives shall be pre-eminant:

a) Surface and shallow subsurface drainage shall not be disturbed to the extent that water is ponded on or at the ground surface on or adjacent to the pipeline right-of-way.

b) There shall be no channelizing of overland flow or other concentrated drainage which could lead to mechanical or thermal erosion. In the case of ditches in right-of-way cuts,the ditch floors shall be protected from erosion by ditch checks, non-erosive blankets of clay or gravel, synthetic fabric mats or any other method acceptable to the Agency.

c) Water draining through mound breaks shall be dispersed over the ground surface on the down-slope side of the pipeline.

d) Sediments, particularly silt particles, entrained in flowing water shall be prevented from reaching any waterbodies or from being deposited on land except in designated areas. Sufficient stilling ponds, settling basins, sediment traps or other devices shall be installed to ensure this.

e) Particular attention shall be paid to the prevention of erosion on the banks of rivers and streams, on all cut-slopes, in right-of-way cuts and on all valley side slopes. Site-specific designs shall be provided for such areas.

15. Separate plans and proposals shall be presented for drainage and erosion control on the pipeline right-of-way for areas of differing construction modes. The following categories are suggested:

a) Areas of "arctic pipeline construction" where the pipeline is built from a snow road along the right-of-way.

b) Areas of "conventional winter construction", where the pipeline is built from a graded winter road.

c) Areas where a surcharge berm is built to control frost heave.

d) Areas subject to inundation by storm surges, ice-jams or other floods.

e) Areas of summer or fall construction, where the pipeline is built from a gravel work pad.

16. Special plans and proposals shall be presented for the design and installation of erosion control measures at all designated stream crossings. In particular special plans will be required at all major river crossings proposed to be constructed in summer. Draft plans are to be presented as part of the preliminary design submission for all designated crossings.

17. In the location, design and construction of facility sites, work pads and airfields, the following objectives shall be pre-eminent:

a) Surface and shallow subsurface drainage shall not be disturbed to the extent that water is ponded on or at the ground surface adjacent to the pads or any other place.

b) There shall be no channelizing of overland flows or other concentrated drainage which could lead to mechanical or thermal erosion. In the case of ditches to lead water around the edge of pads and airfields, the ditch floors shall be protected from erosion by ditch checks, non-erosive blankets of clay or gravel, synthetic fibre mats or any other method acceptable to the Agency.

c) Water draining away from pads or airstrips shall be dispersed over the ground surface.

d) The side slopes of all pads shall be protected from eroding.

e) Particular attention shall be paid to drainage and erosion control at all sites used during construction of the pipeline but then closed down and not used during operations and maintenance. This includes, but is not limited to borrow sites (especially borrow sites on river flood plains), spoil disposal sites, wharves,

stockpile sites and the work pads used in the construction of major river crossings.

f) Sediments, particularly silt particles, entrained in flowing water shall be prevented from reaching any waterbodies or from being deposited on land except in designated areas. Sufficient stilling ponds, settling basins, sediment traps or other devices shall be installed to ensure this.

g) Any drainage water from a pad that contains any petroleum products or other chemicals shall be trapped, contained and disposed of according to the provisions of the section on "Spill Prevention and Control".

18. In the location, design and construction of all roads and trails, whether permanent or temporary, the following objectives shall be pre-eminent:

a) Surface and shallow subsurface drainage shall not be disturbed to the extent that water is ponded on or at the ground surface adjacent to the roadway or any other place.

b) There shall be no channelization of overland flow or other concentrated drainage which could lead to mechanical or thermal erosion. In the case of roadside ditches, the ditch floors shall be protected from erosion by ditch checks, non-erosive blankets of clay or gravel, synthetic fabric mats or any other method acceptable to the Agency. No roadside ditches shall be excavated in permafrost terrain.

c) For permanent project roads and temporary roads that are to be in place during the summer, sufficient through grade culverts shall be installed to allow the free passage of overland drainage. Each culvert shall be equipped with a ditch block or diversion structure to minimize flows of water alongside road berms.

d) Permanent project roads and temporary roads that are to be in place during the summer shall have appropriately sized and constructed culverts at all stream crossings. The culverts shall be sized and designed in accordance with the Fisheries Service Guidelines. Bridges shall be

used in place of culverts if required by the Agency or the Fisheries Service. Low water crossings shall not be constructed in such roads.

e) For the requirements associated with snow roads, reference should be made to that section.

19. The Company and the Agency shall agree on the schedule, level of detail and scale of presentation review and approval of submissions regarding drainage and erosion control measures.

SOURCES OF INFORMATION

1. Transcripts, Exhibits, Basic Documents

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COPE/ITC	Barry, T. (122:18589-92); Lewis, C.P. (124:18902-04; 19055-62)
Delta	Faulkner, R.L. (115:17459-64, 17495-96); Mainland, G.G. (114:177291-92, 17330, 17365-67, 17372, 17389-95); Rempel, G. (116:17649)
EPB	Adam, K. (46:6107-18; 47:6301-13; 72:10778-812; 106:16163-65; 107:16348-50; 108:16500-06); Bliss, L.C. (46:6132-35); Templeton, C.H. (47:6289-91; 108:16500-06)
Comm. C.	Lewis, C.P. (70:10581-87); Longlitz, D. (70:10556, 10561; 71:10685); Owen, E.B. (70:10526); Sprague, J. (136:20652)
Exhibit	844: Environmental implications of Foothills project amendments.
CAGPL	Application: Sections 8.b.1.3, 13.a.6 and 14.d.N.6
	Responses: Questions 18,25,27,29,31-35,41 and 42
FH	Application: Sections: 3B-2, 3B-8, 3D and 5D-5
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2. Reports

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CROSSINGS: DESIGN FLOWS AND LEVELS

GENERAL RECOMMENDATION

It is recommended that the uniform design flow and design level criteria presented below be accepted for all river engineering designs, to ensure conservative design and to reduce the potential adverse environmental impact.

DISCUSSION

Any designs related to a natural waterbody normally require some design flows or design levels, the assumed worst conditions against which the project is designed. Except in the case of major undertakings, such as large dams or diking projects, the assumed design conditions are always well below the worst possible conditions which implies that some risk is accepted. There are three basic aspects to risk taking:

a) Cost: Failures need to be repaired and some failures interrupt or impair the operation of the facility (e.g. the pipeline). Economic criteria suggest that the costs of failures should not exceed the cost of improved initial construction that would have avoided the need for repairs.

b) Safety: Certain failures cannot be tolerated because they involve danger to life. This is at present a rather controversial topic in engineering circles. It has been pointed out recently that society saves vast sums of money by building highways and other works in such a way that they constitute a significant danger to life -- they could be much safer at a price -- while spending lavishly on constructing dams which are almost 100% safe even though some could fail and cause only minor loss of life.

c) Environment: Certain failures (or the repairs of failures) are associated with such undesirable environemntal consequences that they cannot be allowed to occur, although it may be impossible to assign a monetary loss to the failure.

Item (a) is of little concern to the Agency but it is widely accepted practice that regulating agencies should state general criteria for dealing with items (b) and (c).

Item (c) is of particular concern here because the main argument for engineering evidence at the present Inquiry has been that failures need to be repaired and that repair jobs have a great potential for causing detrimental impacts (Williams, 82:12257, 12258).

In selecting such criteria, one has to keep in mind that the stiffer the criteria that are set, the larger the structure will be and the greater the initial impact. It may be desirable to accept occassional failures in return for less initial disturbance.

Criteria Required

The primary requirement is for a design flow criterion for pipeline crossing design, but other flow criteria which will need to be determined include the maximum flows to be expected during the period when the crossing is to be built, design flows for road crossings (culverts or bridges), design flows for gravel mining in channel zones and on flood plains and drainage design flows.

Water levels rather than flows need to be specified in situations involving severe ice jams, lake levels and tides or storm surges in coastal areas.

Design Flow for Pipeline Crossings

The problem of selecting appropriate design flows is identical for both Applicants, although they have taken rather different approaches. The Arctic Gas approach emerges clearly from the cross examination of Cooper by Scott (25:3062-80; 28:3497-500; 29:3562-64). For its preliminary designs, it has us3d a so-called "envelope curve" on a drainage area vs. peak flow graph for most streams (CAGPL Application 14.d.N, 4.3.2, and the 100-year flood on the Mackenzie.

Foothills' consultants, UNIES Ltd., use for their basic criterion the 1:1000 year flood (Spafford' 65:9482-83).

Alyeska designs its stream crossings to withstand the so-called "standard project flood", which is considerably more conservative than the 100-year flood (25:3076-80; see also Recommendation 1).

Other Design Flows

The design flows for construction planning, for bridges and culverts and for gravel mining schemes have received little attention in the hearings except for the drainage flows, which will be considered elsewhere.

The EPB draft code mentions the 50-year flood for bridges and culverts (EPB, 1974; Wilimovsky, 48:6406).

Design Water Levels

Water levels rather than flows have to be specified in situations involving river ice jams, lake levels, or tides and storm surges along coastlines. Neither of the applicants states clearly how it intends to determine design water levels due to ice jamming, but Acrtic Gas has several years of breakup observations. Besides this, there is some published material on spring breakup levels along the Mackenzie River but virtually no data exist for other sites. Storm surges in the Beaufort Sea have been studied as part of the Beaufort Sea Project and are now reasonably well understood. A computer model exists, which permits the computation of water levels along the delta coast for assume meteorological conditions.

RECOMMENDATIONS

1. Pipeline crossings of all designated rivers are to be designed to withstand standard project flood conditions. The standard project flood is a flood estimate based on the assumption that the most severe storm or other meteorological conditions considered reasonably characteristics of the specific region is occurring (Snyder, 1964). The largest flood considered physically possible if all flood-producing factors were to combine (probable maximum flood) is normally about twice as large as the standard project flood.

2. Design water levels due to ice jamming or to storm surges, or any other meteorological or hydrological design criteria affecting the design of the designated stream crossings are to be determined in such a manner that they are at least as conservative as the standard project flood. This means that the most severe meteorological or hydraulic conditions reasonably characteristic of the general region have to be assumed in determining design levels. This is generally achieved by transposing the most severe conditions ever observed anywhere in the region to the site of interest.

3. Design flows and levels for all other (non-designated) stream crossings are to be selected in such a manner that they are reasonably consisent with (i.e. bear same degree to risk as) the standard project flood but individual standard project floods do not need to be determined. A regional analysis based on mutiple regression of design flows on drainage basin parameters or based of the grid-square technique would be acceptable.

4. Permanent stream crossings of access roads are to be designed to withstand 1-in-50 year conditions of flow or water levels.

Temporary facilities such as work pads in rivers, perimeter dikes of gravel mining schemes in channel zones, coffer dams etc., are to be designed on the basis of a 1-in-25 year probability level.

6. The last two design flow specifications refer to the probability at which the safety of the structure from flood damage has to be assured. Many of these structures will also have to meet certain hydraulic criteria for fish passage described elsewhere.

7. Besides determining the appropriate design flows and levels, the Company is to submit as part of the preliminary design submission, all supporting data and computations to the Agency for review. A separate submission is needed for each designated stream crossing while all other crossings can be dealt with on a spread-by-spread or regional basis.

Comments on Recommendations

There are few streamflow and water level data along the northern part of the pipeline route, but more meteorological data have been assembled. Hence, it is reasonable to recommended adoption of a meteorologically based design flood criterion (standard project flood).

The 1-in-25 year and 1-in-50 year floods are specified for some designs, but they cannot be determined accurately with presently available data. The intent is that the specified return periods should be used as rough guides in applying engineering judgement. If the project is delayed a few more years, the data base for final design will be much better and the specified return periods could then be taken more literally. The Mackenzie Highway culvert design flows are based on 50-year floods (Kite, 1974) besides having to meet several fish passage requirements, that are often more stringent.

SOURCES OF INFORMATION

1. Transcripts, Exhibits; Basic Documents

CAGPL Cooper, R.H. (25:3062-80; 28:3497-500; 29:3562-64); Williams, G.L. (82:12257-58)

FH Spafford, G. (65:9482-83)

EBP Wilimovsky, N.J. (48:6406)

CAGPL Applications: Section 14.d.N and 4.3-2.

2. Reports

Environment Protection Board
1974 Environmental impact assessment, Vol. II.

Kite, G.W.
1974 Case study of regional techniques for design flood estimation, Can. 3, Earth Sec. 1, Vol. II, p. 801

Snyder, F.F.
1964 ASCE proceedings, No. HY3

REVEGETATION

GENERAL RECOMMENDATIONS

The Company shall revegetate all disturbed land surfaces resulting from the construction, operation, and maintenance of the pipeline for the primary purpose of controlling erosion.

Secondary objectives should be the re-establishment of native vegetation and the lessening of aesthetic impact.

DISCUSSION

The construction, and to a lesser extent the operation, of a Mackenzie Valley gas pipeline and its ancillary facilities will result in the removal of the vegetative cover over much of the right-of-way.

In northern areas this vegetative cover, together with its underlying organic mat and more extensive network of roots, plays a vital role in terrain stability. In permafrost areas, removal of the plant cover and the organic mat can change the soil thermal regime, thereby increasing the thickness of the active layer in summer and causing permafrost degradation. In sensitive permafrost areas, where the soils are fine-textured and ice rich, this additional thawing can lead to a variety of instability problems, such as subsidence and slumping. In both permafrost and non-permafrost areas the plant cover prevents wind erosion and various forms of water erosion, such as sheet, rill, and gully erosion. Therefore, the removal of the plant cover can start processes that could threaten the stability of the facilities and cause such environmental damage as impeded drainage and silted water courses.

Of these potential impacts only erosion appears amenable to control by revegetation of the disturbed surfaces and then only in conjunction with the appropriate drainage and erosion control procedures. The control of permafrost degradation cannot be achieved in the short term by newly established vegetation; therefore reliance for its control must of necessity be on wholly non-biological means. The two Applicants recognize this and it is reflected in the stated objectives of their respective revegetation programs.

The proposed revegetation programs of the two Applicants have similar objectives, i.e. to control erosion by promoting the re-

establishment of natural plant communities. There are, however, fundamental differences in their approach. Arctic Gas is relying primarily on agronomic varieties of grasses to provide the initial ground cover required to control sheet and rill erosion. Native species have only a limited and secondary role. Hard and soft wood shrub cuttings will be used in the revegetation of slopes and the seed of two native grasses, *Calamagrostis canadensis* and *Arctagrostis latifolia*, will form some part of the seed mix. Foothills, on the other hand, proposes to use only native species in its programs, and has an apparent greater reliance on vegetative methods (including cuttings) than does Arctic Gas.

The success of either of these revegetation programs is dependent on a stable soil surface. Neither of the Applicants has demonstrated that this can be everywhere achieved, especially on slopes or cuts in ice-rich permafrost soils. Foothills has yet to conduct slope stablization tests. Arctic Gas on the other hand has conducted several small scale and separate tests but has attempted no large scale integrated test of such procedures. It would appear that a large scale test of the proposed revegetation procedure for slopes in an area of high potential erodibility is required.

The two Applicants recognize that their proposed revegetation programs will not initially be everywhere successful in establishing a complete vegetation cover and that follow-up revegetation is required.

As such follow-up seeding programs will occur primarily in the summer there is a potential for conflicts with wildlife populations. There is a concern that the resolution of such conflicts will be at the expense of the revegetation program. It is important that the revegetation of any area be at a time appropriate to the establishment of the vegetation and not be governed solely by the desire to avoid contact with any specific wildlife population. In any adjustments to the revegetation program from such conflicts, or for any other reason, priority in revegetation should be given to areas most susceptible to erosion, as opposed, for instance to relatively level areas where the erosion hazard is low.

RECOMMENDATIONS

1. Revegetation shall be planned and implemented as a complement to other drainage and erosion control measures rather than as an end in itself. First priority shall be given to areas where there is a high potential for erosion and major concerns over the environmental impact of erosion.

   The Company will ensure that revegetation (together with the necessary clean-up, re-grading, preparation of drainage and erosion control structures etc.) is completed promptly after termination of pipeline construction activity or other land-use of the site.

   To this end priority will be placed by the Company on the manpower, logistic and supply requirements of the revegetation program needed to meet the planned revegetation schedule.

2. The Company shall, as part of its preliminary design, demonstrate to the Agency by an approved field test or tests in the project area the suitability of its proposed revegetation procedures for the control of erosion on slopes and cuts.

3. The Company shall, at the design review stage, submit to the Agency its general plans for revegetation of the right-of-way and other disturbed areas. This plan shall indicate the kinds of seed mixtures and where they will be used, the vegetative methods to be used and where, the amount and type of fertilizer, the types of equipment and their application and timing. The appropriate documentary evidence in support of these procedures shall also be included.

4. The Company shall submit to the Agency following the submission of its general plan a specific revegetation plan for each spread detailing manpower requirements and training, logistics, the seed mixes to be used and their rates of application, fertilizer type(s) and rates of application, methods and timing of application, vegetative methods and their application, expected follow-up, revegetation requirements, and procedures to be applied to minimize environmental impacts. These revegetation plans shall also demonstrate how the procedures and the seed-mixes and

fertilizer will be adjusted in keeping with changes in topography, soil and drainage.

5. Where site-specific erosion control plans are necessary, the Company shall include the required revegetation procedures as a specific component of this plan.

   Information shall be provided to the Agency on the source(s) of the plant material required for revegetation, manpower and aircraft requirements for the collection and placement of the plant material, support camp location, timing, and potential conflicts with wildlife population.

6. The Company shall, as an integral component of its initial revegetation program, monitor the short term success and shall repeat the revegetation measures where required until they are successufl. The control of erosion shall be the primary objective of such follow-up revegetation; aesthetic considerations shall be secondary.

7. The Company shall monitor, as a part of its operations and maintenance program, the long term success of its revegetation program. Supplementary seeding will be limited to that required for the control of erosion and will not be allowed for only aesthetic or cosmetic reasons. This approach will limit the long term persistence of non-native species along the right-of-way and will encourage the re-establishment of native plant species.

8. The Company shall ensure that any requirements for summer revegetation, whether initial or supplementary, integrate both the needs of the plants for establishment and the avoidance, where possible, of conflicts with wildlife.

SOURCES OF INFORMATION

1. Transcripts, Exhibits, Basic Documents

CAGPL	Dabbs, D.L. (79:11712-31; 82:12292-329); Harlan, R.L. (39:5153-54); Jakimchuk, R.D. (94:14254-61); Minning, G. (78:11618-19); Williams, G.L. (19:2215-16)
FH	Bauer, A.F. (67:9952-59); Vartnou, H. (86:12853-71; 87:13121-32)
EPB	Bliss, L.C. (109:16685)
PAAG	Report

2. Reports

Environment Protection Board
1974 Towards on environmental code.

CROSSINGS: DEFINITIONS

GENERAL RECOMMENDATION

Enforceable regulations require clear definitions; this paper attempts to define and clarify those technical terms related to hydrology whose definition is uncertain.

All definitions of fluvial terms are assembled here, although some of them are needed in connection with matters other than stream crossings (e.g. borrow from rivers).

DEFINITIONS OF WATERCOURSES

DISCUSSION

Strictly speaking, any identifiable trace of concentrated runoff water could be called a stream. Pipeline construction, however, involves at least four different levels of effort in crossing such streams and it is thus desirable to gear any regulations towards these four levels, but without giving the pipeline company control over the classification for regulatory purposes.

Both Applicants propose to identify all watercourses (as defined subsequently) by walking the line after clearing, to ensure that none are missed. At the lowest level, small intermittent drainage courses will be treated as part of drainage and erosion control. This involves mainly the provision of berm breaks, but no sag bends, and therefore does not affect the pipe itself. The remaining three levels involve some type of stream crossing design. The second group of watercourses comprises small streams for which "typical" crossing designs will be used. The third group requires site-specific designs and procedures. All these first three groups of crossings are to be executed as part of the main pipeline construction by the spread contractor. The last group comprises a few of the larger stream crossings, which may be built under separate contracts and possibly at different times of the year than the main pipeline.

The question of how big a watercourse has to be to become the subject of a stream crossing design (typical or site-specific)

has been debated several times during the Inquiry and has undergone a certain amount of change.

Arctic Gas appears to believe that there are approximately 650 streams to be crossed in Canada North of 60°N, 150 of which require individual designs. Statements by Hollingshead and Harlan in NEB hearings (NEB 2854, NEB 2273) provide a basis for placing the minimum drainage area for a site-specific design at 10 square miles and the minimum area for a typical stream crossing design at 1 square mile.

Arctic Gas' definition of a "major" river crossing is stated by Clark: "We have a classification of major and minor river crossings that actually relates to the manner in which they are built. Usually, a major river crossing is one that is handled by a separate contractor, a minor river crossing is one that is handled by the contractor dealing with that particular spread" (28:3459).

Spafford attempts a somewhat more comprehensive definition on behalf of Foothills: "The way one defines a major river is quite controversial. We define it more on a point of view of difficulty of crossing the river and it may or may not have been influenced by the volume of flow. Our criteria were, I believe, in excess of 100 foot high banks, 30 percent grade or greater and 20,000 cfs design flow or greater, any one of these factors would qualify it as major" (64:9422-23). Neither of the above usages appears to be of use to the Agency.

What does matter to the Agency is that the pipeline company undertake appropriate hydrological and biological studies and come up with a design and a construction procedure which do not damage the stream. The definitions presented here are meant to serve as a basis for specifying the extent of studies to be undertaken before interfering with streams, and the procedures to be followed for obtaining permits to proceed with construction.

In the present document, watercourse is meant to be the all-inclusive term without any implication of size. Drainage courses are the small watercourses for which the drainage and erosion control procedures are obviously applicable, without hydrological or biological work beyond the initial map and field identification; whereas streams are watercourses that need to be investigated hydrologically and biologically. The groups of designated streams and designated major rivers are introduced as

some further subdivision of the large number of streams and rivers according to potential impact.

RECOMMENDATIONS

1. The following definitions of watercourses should be used by the Company and the Agency in river engineering design:

   a. Watercourse: Any identifiable trace made by concentrated runoff water on the earth surface.

   b. Drainage course: All watercourses smaller than streams as defined below.

   c. Stream (also river, creek): Watercourses which seasonally offer habitat suitable for fish and/or have an average stream channel width greater than 3 feet and/or carry perennial flows in excess of 0.05 cfs and/or have a drainage area greater than 1 square mile.

   d. Designated stream (also designated river): A stream or river for which site-specific crossing designs and procedures are required by the Agency. The following streams will be designated: streams with drainage areas greater than 10 square miles; streams with the potential for significant channel shift and scour at the crossing site; streams which support significant fish populations at some time of the year in the vicinity of the crossing site; and streams where the pipeline crossing involves potentially significant technical or environmental hazards.

   e. Designated major river: A river likely to be crossed on the basis of separate construction contracts and/or a river to be crossed at times that are significantly different from the main pipeline construction. The following river crossings are included in this category: Great Bear, Peel, Mackenzie River, main Mackenzie Delta distributaries and Shallow Bay. Others that possibly would be included are Firth, Old Crow, Hare Indian and Willowlake. The latter two are noted in the Foothills Application.

2. At the time of submission of the preliminary river crossing design or earlier, a complete listing of all designated streams and all major rivers should be prepared by the Agency (in consultation with the Company) to serve as a reference in design review.

DEFINITIONS OF VALLEYS

DISCUSSION

There is considerable confusion in the transcripts and applications concerning names for the various features of a river valley. As certain pipeline related facilities or activities will be located in or close to rivers agreed-upon definitions will be needed as a basis for regulation.

Both applications use the terms "active flood plain", "fossil flood plain", "alluvial meander plain" and "high terrace", and the transcripts include discussion regarding definition of these terms and use of the term "active channel" (Cooper, 21:2466-67; 26:3128-29; Lewis, 70:10567-71; McCart, 83:12445-46). The proposals made here for use of "stream channel", "flood plain" and "terrace" correspond to widely accepted engineering practice (Cook et al., 1975; Kellerhals et al., 1976) and are generally similar to the usage proposed by Lewis.

RECOMMENDATIONS

3. The following definitions of valley components should be used by the Company and the Agency in river engineering planning:

   a. Stream channel (or river channel) zone: Generally the smaller of the following two areas:

      the area between the top of distinct stream banks or between distinct trim-lines of forest or tundra vegetation; or

the stream channel area covered by flowing water at least once in two years on a long term average. In the case of braided streams (characterized by multiple, laterally unstable channels), the channel zone includes the entire braided zone.

b. Flood plain: Low-lying area adjoining a stream channel, underlain by alluvial (river-deposited) materials and subject to occasional flooding (at least once in 100 years on a long term average).

c. Terrace: Area that was a flood plain at some earlier geologic time but is now relatively higher above the stream (the stream may have incised itself) and therefore not subject to flooding, or only subject to very infrequent, minor flooding.

SOURCES OF INFORMATION

1. Transcripts, exhibits, basic documents

CAGPL	Clark, J.I. (28:3459); Cooper, R.H. (21:2466-67; 26:3128-29); McCart, P.J. (83:12445-46)
FH	Spafford, G. (64:9422-23)
Comm. C.	Lewis, C.P. (70:10567-71)

2. Reports

Cook,
1975 Journal of the hydraulics division, ASCE, Vol. 101, No HY7.

Kellerhals, R. *et al*.
1976 Classification and analysis of river processes; Journal of the hydraulics division, ASCE, Vol. 102, No HY7.

National Energy Board
1976 Transcript, Mackenzie Valley hearing, GH-1-76: CAGPL evidence, pp. 2273, 2854.

CROSSINGS: DESIGN CRITERIA

GENERAL RECOMMENDATION

River crossing designs shall incorporate criteria for avoiding or reducing environmental impact, and shall be adjusted so as to reduce the possibility of crossing failures leading to environmentally disruptive contingencies and repairs. The criteria proposed relate to crossing location, location of sag bends, river training works, effects of the frost bulb, crossings, buoyancy control, scour computations, dual crossings and frost heave.

INTRODUCTION

Developing a design code for pipeline river crossings falls outside the terms of reference of this Inquiry, but certain engineering aspects of the crossing design have definite environmental implications. The first five sub-sections below deal with matters of this nature. The other major justification for dealing with engineering aspects of pipeline design relates to the repair of failures. Certain types of failures may be quite tolerable from a narrow engineering point of view because they either do not threaten continuity of gas supply or can be repaired quickly enough to keep the interruption of supply within tolerable limits. Accepting the chance of infrequent failures of this type may be cheaper in the long term than taking adequate measures to prevent them, yet, from an environmental point of view, the repair work may be very damaging because it will normally have to be undertaken at the time of the failure, a time that may be most unsuitable. This concern is shared by Williams and Harlan (82:12257-67) and it is well illustrated with the case-history of the Kotaneelee River crossing (25:3001; 69:10399). The final four sub-sections deal with items of this type.

It is basically the Company's responsibility to design and construct a safe and environmentally sound pipeline. Considerable restraint should therefore be exercised in imposing specific engineering solutions by regulation.

The present recommendations are meant to provide guidance to the designers and to the review agency, in order to facilitate an early meeting of minds. Without detailed design review process by an outside regulating agency, the present design criteria would be meaningless.

In the following discussion where escape clauses are not included, it is intended that the Agency may respond to requests by the Company for relief from a particular requirement, where convincing evidence is presented that the requirement is unnecessary or inappropriate.

LOCATION OF CROSSINGS

DISCUSSION

Some of the most difficult geotechnical problems in pipeline design arise in connection with stream crossings. Clark states that the pipeline location was to a considerable degree governed by the location of suitable stream crossing sites (19A:2238). One major problem, which is considered elsewhere, is the stability of the river bank or valley wall slopes. Other problems more directly related to rivers include the importance of crossing locations, the sensitivity of discrete reaches of rivers, possible shifts in stream course, and the proximity of highway and pipeline crossings.

RECOMMENDATIONS

1. Certain sections of most rivers and river valleys should be avoided by river crossings because of technical difficulty or because of environmental or land use concerns. Therefore, selection of crossing locations to avoid such unsuitable sites should precede finalization of the route of the pipeline.

2. The potential for the stream course and the pipeline to run parallel, as a result of a shift in the stream course, shall be prevented by careful siting of crossings in reaches where the stream is stable and straight. The pipeline shall cross flood plains and channel zones as directly as possible (20:2400; 78:11657; PAAG p.223).

3. A site-by-site evaluation is necessary to determine the approach to be adopted where highway and pipeline crossings are close together. Safety, aesthetics and certain geotechnical problems tend to suggest wide separation but close spacing might minimize the impact on fisheries and facilitate future maintenance (78:11653-54; 109:16671-72; PAAG pp.351-53).

4. Where preliminary pipeline crossings of designated streams fall within one mile of a permanent road crossing of the same stream, the Company shall decide the most desirable separation and then justify its proposal before the Agency. The Agency may specify a distance of separation.

LOCATION OF SAG BENDS

DISCUSSION

As rivers flow in single, well defined and stable channels, the sag bends are located a relatively short distance land-ward of the river banks, thus allowing for minor bank erosion and channel shift over the life of the pipeline. Potential conflicts arise mainly when crossing wide, braided channels or channels which migrate at significant rates across a flood plain, because there the designer can either locate the sag bends outside the present and potential future channel zone, burying the pipeline deeply all across these channel zones, or he can squeeze the channel zone with river training works and build only a short river crossing. The environmental effects of the two alternatives differ as the first involves considerably more initial work but less permanent interference with the river than the second. Clark and Hollingshead explain the basic design problem (19:2228-29; 21:2434-35) and Cooper gives a clear commitment to adopt the preferable, first alternative (21:2467). In the case of significantly meandering channels, Hollingshead states that Arctic Gas could either locate the sag bends beyond the furthest point that the meandering channel could ever reach or they could be placed fairly close to the present channel. If, after some years, monitoring shows that the channel is getting close to a sag bend, training works could be built to stabilize the channel (21:2435).

Either technique can also be applied to a similar problem which occurs at the western end of the Shallow Bay crossing, where the shoreline recedes at roughly 25 feet per year (132:20008-09; 20052-53).

From an environmental point of view, the first alternative of placing the sag bends well outside the present or future channel zone is commonly preferable because it reduces the risk of major repair or maintenance work. The reasons why the second alternative -- river training works -- is undesirable as discussed below.

The matter has not arisen in connection with the Foothills Application, but the concern is of a general nature and applies to all stream crossings. It becomes particularly important along the Arctic Gas Coastal Cross-Delta route with the braided streams of the Yukon North Slope, and at Shallow Bay.

RECOMMENDATIONS

5. The sag bends of all designated stream crossings are to be located far enough beyond the channel zone to assure that they will still be outside the channel zone by a safe distance after 50 years of natural, unimpeded channel zone migration. The Agency may waive this requirement if the Company can show conclusively that deep burial beyond the channel zone will do more damage than the construction of river training works needed to avoid deep burial.

RIVER TRAINING WORKS

DISCUSSION

River training works to alter the direction of river flow or to contain it in a fixed or confined passage can be proposed in a variety of circumstances. For instance, the channel zone of rivers can be narrowed permanently to reduce the length of river crossings, or be confined temporarily to make room for a borrow operation in the channel zone; the normal process of meander migration can be arrested to provide a stable river crossing site, or training works can be built on the flood plain to prevent future meander cutoffs or other channel relocations.

Training works may interfere considerably with a river by obstructing fish, causing siltation or can be plain ugly. Moreover, a high percentage of them fail, thereby magnifying detrimental effects. This danger is particularly acute on the Yukon North Slope, where factors such as icings and permafrost add to the difficulties. While Clark (19:2228) is of the opinion that all necessary design tools are available, Lewis (70:10584) doubts this, particularly with regard to the Yukon North Slope. There is a definite possibility that the cheapest design of a pipeline across the Yukon North Slope could involve extensive river training works (Williams, 132:20046). This is a major concern. However, concerns over the environmental effects of river training works are not confined to the Yukon North Slope: rather such works would be of concern at any crossing along any of the proposed pipeline routes and alternatives.

RECOMMENDATIONS

6. Permanent river training works in the channel zone are to be avoided wherever possible. Unavoidable training works aimed at preventing a river from taking off along the pipeline right-of-way or from entering a flood plain gravel pit, or designed to prevent cut-offs or avulsions, are to be located preferably on flood plains rather than in channel zones.

EFFECTS OF THE FROST BULB

DISCUSSION

There is a certain amount of groundwater flow in the alluvial materials below most rivers and their flood plains. The quantity of water involved is normally very small compared with the river flow but, in the case of rivers which dry up during certain parts of the year, it may nevertheless have great biological significance. In permafrost areas many rivers do freeze up, but the groundwater flow may maintain pools of water in some deep parts of the channel or may emerge as springs at certain locations along the channel (28:3437-55). These restricted areas of water can be crucial for overwintering fish and eggs (see "Fish Protection"). A pipeline buried in the alluvial materials below a river and carrying gas at temperatures below freezing might, in time, choke off the groundwater flow by the growing

frost bulb. The groundwater would then emerge just upstream of the pipeline crossing and probably form an icing there. The fish, accustomed to overwintering at certain downstream locations, could be left without water (79:11739; 84:12533).

Arctic Gas mentions a number of tentative solutions to this problem without making any commitment to adopt any one (26:3224; 28:3481). It agrees with Adam and Lewis on the need for further research and indicates that this is presently under way (46:6108-09; 70:10592-93; 73:10967-68). There is broad agreement among witnesses that the frost bulb effects on groundwater flow below streams are a serious concern, and that both the problem and the proposed solution are not yet adequately understood. It is probable that, given sufficient time and funds, design solutions to overcome this problem are available and there is always the possibility of crossing overhead thereby avoiding the problem entirely.

Although this potential problem is most graphically evident in the case of pipeline crossings on the Yukon North Slope, it is also of substantial concern relative to crossings of small streams along the Mackenzie Valley and elsewhere.

It should be noted that the existence of a problem concerning groundwater flow at a river crossing can not be known definitely without site-specific knowledge of winter river and groundwater flow over a number of years, the winter aquatic ecosystem, and the crossing plan. Likewise, design of any mitigative measures requires the same detailed knowledge.

RECOMMENDATIONS

7. Preliminary design proposals for all designated stream crossings (and for any other crossing required by the Agency) will be accompanied by conclusive evidence that:

    (a) maintenance of groundwater flow in the general area of the crossing in winter is not of environmental importance; <u>or</u>

    (b) maintenance of such flow is of environmental importance but that installation of a crossing without special mitigative measures will not have adverse environmental effects.

Where the above conditions can not be met (i.e. where special protection measures are known to be needed or where there is no conclusive demonstration that they are not needed) the crossing design will incorporate measures that assure continued winter groundwater and channel flow across the installation so as to provide adequate protection of fish populations and the aquatic ecosystem that supports them.

8. The Company will build and test a physical model of a stream crossing little or no winter channel flow but significant groundwater flow. This model will demonstrate that the proposed means of assuring groundwater flow across the frost bulb are effective, and that the structures can be installed without significantly increasing environmental impact of the construction process. Its effectiveness in maintaining the following parameters shall be demonstrated:

   (a) a similar flow of water across the frost bulb to points downstream, as would occur naturally;

   (b) normal physical water quality characteristics such as suspended sediment, dissolved oxygen, and temperature;

   (c) normal chemical water quality characteristics such as pH, conductivity and colour; and

   (d) normal invertebrate and fish communities (including eggs) in overwintering areas downstream.

OVERHEAD CROSSINGS

DISCUSSION

Although overhead crossings are not part of either application for the mainline -- Foothills plans to supend community laterals from existing highway bridges (Fawcett, 60:8559) -- they provide a technically feasible alternative for crossing most streams (22:2666; 24:2817-19; 25:2976; 30:3890; 62:8868). Pipeline designers generally do not like them because they introduce construction and maintenance problems that are almost totally different from those found along the rest of the buried line. Overhead structures are also vulnerable to sabotage and vandalism (Horte, 56:7861-62).

There are at least four reasons why overhead structures may be environmentally preferable to buried crossings at certain sites (Adam, 46:6109-10; 85:12648):

(a) slope stability and erosion problems arising at narrow, deep valleys can be avoided (Mirosh and Walker, 62:8862-73);

(b) the difficult ice scour problems at Point Separation can be avoided;

(c) there would be no frost bulb to interfere with groundwater flow; and

(d) there would be no frost heave.

Environmental problems associated with overhead crossings are relatively minor and reasonably well known. Large overhead crossings present a hazard to helicopters and planes.

Combined pipeline-highway overhead crossings are feasible as evidenced by Foothills' plans for community laterals and might make highway bridges possible that could otherwise not be justified. Unfortunately this matter has never been resolved in the evidence, although there are oblique references to it (Horte 56:7860-61; Phillip, C-4:198-200). The Alyeska line crosses the Yukon River on a joint pipeline-highway bridge (Carlson et al., 1976).

Difficulties with construction and maintenance make pipeline builders very reluctant to consider overhead crossings, although many existing overhead crossings indicate that these difficulties can be overcome. Regulations should assure that the overhead alternative, which deals effectively with several major environmental concerns, is not rejected purely for reasons of convenience.

RECOMMENDATIONS

9. Where preliminary design review indicates that a buried crossing would involve substantial unresolved environmental concerns, the Agency should instruct the Company to prepare a comparison of the buried crossing with an overhead crossing and to justify its choice of crossing mode in both engineering and environmental terms.

BUOYANCY CONTROL

DISCUSSION

Buoyancy control at river crossings involves standard procedures that would be expected to give rise to environmental concerns only under the rare conditions when repairs are required in sensitive locations and at sensitive times. On the other hand, use of less-than-complete buoyancy control outside of the channel itself in the periodically inundated flood plain area involves a greater possibility of buoyancy control failure and thus of environmental damage during repair.

RECOMMENDATIONS

10. Buoyancy control weights that cannot slip off or anchors are required at river crossings for the entire length of pipe submerged under design flow conditions. Where a concrete jacket around the pipe is proposed, the Company shall demonstrate that the jacket cannot crack and spall.

11. Concrete weights that can not slip off are to be applied to all parts of the pipeline system on the Mackenzie Delta.

SCOUR COMPUTATIONS

DISCUSSION

Scour computations are essentially an engineering problem and environmental aspects are involved only if the computations are badly wrong, leading to a failure that needs to be repaired almost immediately. Considerable evidence on this topic has been presented to the Inquiry because some aspects of river bed scour along the proposed routes are without precedent and involve poorly understood phenomena. This applies to the following in particular:

(a) scour under massive ice jams such as those observed upstream of Point Separation on the Mackenzie River (Clark, 20:2396; Cooper 25:2964; Cooper and Hollingshead, 132:20042-43);

(b) scour or gouging by up-ended ice cakes during breakup (Cooper, 25:2990);

(c) migration of the very deep and partly unexplained scour holes observed in the Mackenzie Delta (Cooper, 25:2981); and

(d) scour associated with spring runoff flowing over and through icings.

Clark explained Arctic Gas' procedures in dealing with river bed scour (19A:2276); and Hollingshead emphasized the need to consider both long term degradation of a river channel and local scour (21:2427-33). Lewis emphasized the need to re-examine scour computation methods developed for southern Canada if they are to be applied to rivers flowing on permafrost (70:10582). Spafford recommended a very conservative approach due to the many unknowns (64:9301; 65:9463, 9485).

The many poorly understood phenomena that can contribute towards river bed scour give rise to some concern but, in view of the close correspondence between the Applicants' interests and environmental concerns, the importance of this topic has to be rated as minor.

RECOMMENDATION

12. The security of all crossings of designated streams against scour or general river bed degradation from any cause is to be assured at a level of risk comparable to the standard project flood.

DUAL CROSSINGS

INTRODUCTION

At certain times of the year, such as freeze-up, break-up and the spring flood, it would be impossible to repair pipeline failures at some of the larger rivers. These are also the times when failures are most likely to occur, because then the various river processes such as scour and bank erosion are most active. Arctic Gas has decided that such risks to its continuity of supply are not acceptable (Williams, 15:1724-27; Dau, 16:1802-03; Clark,

24A:2907-08, 2944) and propose dual crossings for some of the major river crossings and for the Cross-Delta route, including Shallow Bay. The crossings are to be separated by approximately one river width or by 200 feet across Shallow Bay.

Foothills, on the other hand, proposes to use single crossings only. Thus Walker has taken the position that, with careful location, design and construction, the risk of failure will be minimal and does not justify the added cost and added environmental disturbance caused by the construction of a dual crossing (61A:8724-25).

Although dual crossings have been proposed by Arctic Gas for economic reasons only, they involve a potential environmental advantage: namely that repairs in the river or on the banks need not be done on an immediate or contingency basis but rather can be scheduled and orderly, with due allowance for environmental protection. In this regard it is noteworthy that both Harlan (82:12257-67) and Hayden (100:15194) see river crossing repairs as of major environmental concern. Of course, at any particular crossing site the chance of major environmental degradation from emergency repair of a single crossing at an unsuitable time has to be weighed against the detrimental effect of building two pipelines rather than just one.

RECOMMENDATIONS

13. The Company's preliminary design submission to the Agency for each designated major river crossing shall include a statement of the environmental rationale involved in the decision to use a single or dual crossing. The Agency may extend this requirement to crossings of other large rivers. The environmental rationale for any dual crossing shall include the approaches as well as the crossing itself (for instance the Arctic Gas plan for the dual crossing of the East Channel of Mackenzie River at Swimming Point involves a crossing of fish-sensitive Holmes Creek).

14. If the project involves a dual pipeline across the Mackenzie Delta, "cross-overs" between the two pipes should be installed during pipeline construction to increase flexibility in repair scheduling.

FROST HEAVE

DISCUSSION

Frost heave is a consideration relative to the Shallow Bay crossing as well as river crossings where the pipe is chilled and the river bed materials are unfrozen and frost susceptible. Clark acknowledges that frost heave under rivers is somewhat different from other frost heave (73:10826) but states that Arctic Gas plans to deal with it using essentially the same techniques as elsewhere. The concept of dealing with frost heave under dual river crossings by alternating the gas flow between the pipes (Clark, 20:2308; 132:20074-75; Slusarchuk, 26:3212-13, 3228). Insulating the pipe has also been mentioned as a solution for smaller streams (Slusarchuk, 26:3226-27).

Environmental concern regarding frost heave of underwater crossings relates principally to the potential impact of repairs, particularly if required at sensitive locations and times. Moreover, there could be ecological changes of concern if frost heave of the proposed dual pipeline under Shallow Bay were to be accompanied by changes in the profile of the bay floor.

RECOMMENDATIONS

The recommendations in the section of this report dealing with frost heave in general cover the concerns relating to heave of underwater crossings.

SOURCES OF INFORMATION

1. Transcripts, Exhibits, Basic Documents

CAGPL Clark, J.I. (19:2228-29; 19A:2238, 2276; 20:2308, 2396; 24A:2907-08, 2944; 28:3437-55, 3481; 73:10826); Cooper, R.H. (20:2400; 21:2467; 24:2817-19; 25:2964, 2981, 2990; 32:20042-43); Dau, P.H. (16:1802-03); Hardy, R.M. (22:2666; 25:3001); Harlan, R.L. (73:10967-98; 79:11739; 82:12257-67); Hollingshead, G.W. (21:2427-35; 25:2976; 30:3890; 32:20042-43; 62:8868; 132:20008-09, 20052-53); Horte, V. (56:7860-62); McCart, P.J. (84:12533); Minning, G. (78:11653-54, 11657); Owen, E.B.

	(69:10399); Slusarchuk, W.A. (26:3212-13, 3224, 3226-28)
FH	Fawcett, M.A. (60:8559); Hayden, W. (100:15194); Mirosh, E.A. (62:8862-73); Spafford, G. (64:9301; 65:9463, 9485); Walker, G.W. (61A:8724-25; 62:8862-73)
EPB	Adam, K. (46:6108-10; 85:12648); Templeton, C.H. (109:16671-72)
Private	Phillip, S. (C-4:198-200)
Comm. C.	Lewis, C.P. (70:10582, 10584, 10592-93)
PAAG	pp. 223, 351-53

2. <u>Reports</u>

Carlson, L.A. *et al.*
1976 First bridge across the Yukon River; Civil Engineering-ASCE; August, pp. 47-52.

CROSSINGS: CONSTRUCTION

GENERAL RECOMMENDATION

Construction of river crossings -- including installation of the pipe, use of pads or berms, and restoration of river bed and banks -- together with the scheduling of construction activity shall be adjusted so as to avoid or limit disturbance of fish and other direct or indirect environmental impacts.

INTRODUCTION

The problems encountered in constructing buried pipeline crossings and the techniques used to overcome them tend to set stream crossings distinctly apart from the remainder of the pipeline. Although river crossings amount to only a small fraction of total pipeline length, they are a major item in the overall project both in terms of cost and in terms of potential environmental impact.

TIMING OF CONSTRUCTION

DISCUSSION

Most pipeline construction activities of Arctic Gas and Foothills are planned for winter, but a major exception is the proposed summer construction of large river crossings and the crossing of Shallow Bay (Clark, 24:2875-76; Dau, 37:4745-49). Since most of these crossings are to be built either from barges or work pads, summer construction should be possible without risking major terrain damage, but the amount of work done on the approaches has to be minimized. Foothills also plans to build large crossings, such as those across the Mackenzie River in summer and smaller ones in winter (Walker, 61A:8723-24). Unlike Arctic Gas, Foothills proposes summer construction for the Hare Indian and Willowlake River crossings but according to Ellwood (C-18:1811) a definite decision on the time of construction for the Hare Indian River has not yet been made.

Construction of a large river crossing, whether done in summer or winter, involves a fairly rigid sequence of different activities (the major ones of which are discussed in subsequent sections). The concern is that even with the best of intentions on the part of the Company, unforeseen delays (common in construction) combined with very rigid overall deadlines could disrupt any environmentally motivated initial schedule. For instance, construction of the Shallow Bay crossing in summer could

potentially be in conflict with protection of white whales, staging geese if even minor schedule delays occur. Another possible conflict involves construction of the crossing of the Hare Indian River and fishing by residents of Fort Good Hope (C-18:1808-10).

The timing of the construction of river training works is uncertain from the evidence. Hollinghead agrees with Scott that river training works have not traditionally been built in winter, and states that Arctic Gas has not yet decided when to build them (25:3019ff). Extensive summer construction of training works could lend to a variety of environmental concerns.

RECOMMENDATIONS

1. The Company shall prepare detailed schedules for all construction work associated with crossings of designated streams and shall submit evidence showing that the schedule is realistic with adequate contingency allowances. Evidence is also required to show that the proposed schedule does not interfere with significant biological activities and resources and that it also does not clash with traditional human activities. The freezing applies not only to the construction but to all logistics associated with it.

2. On request from the Agency, the Company shall draw up construction plans for crossing selected designated streams at times other than winter, and shall evaluate these plans for feasibility, cost and environmental impact. These plans will be implemented if so requested by the Agency.

3. Summer construction of new training works is to be avoided, unless all necessary materials and equipment can be brought to the site by water or by air.

4. The approaches to summer-constructed river crossings are to be built in winter.

INSTALLATION OF THE PIPE

DISCUSSION

The various methods of installing the pipeline below the stream bed give rise to a number of closely related concerns. Easiest to cross are winter-dry streams, particularly if the excavation for the pipe ditch does not intersect taliks (unfrozen ground) below the channel zone. Such stream crossings can be installed as part of the normal pipe-laying procedure. Frequently the pipe ditch will intersect taliks below the stream and this will complicate construction because any excavation will fill with water which will tend to freeze rapidly. In order to avoid significant interference with the groundwater flow, it will be necessary to minimize the time between excavation of the ditch and backfilling. Contamination of the groundwater with the excessive silt or with hydrocarbon spills will also have to be avoided.

The sections of this report on "Fish Protection" have outlined the environmental problems involved in winter crossings of streams carrying limited flows and containing overwintering fish or eggs. It is hard to predict which streams will be flowing (Spafford, 64:9436). The pipeline crossings have to be installed without interrupting the flow and without damaging the downstream reach through sedimentation. The following measures can be used to minimize impact:

a) Speed: if the time during which the stream is being disturbed can be kept very brief, a certain amount of flow interruption and sedimentation may be tolerable.

b) Diversion: depending on local circumstances it may be possible to divert the stream through a temporary culvert around the stream crossing site while the crossing is being installed (64:9419; 84:12555).

c) Pumping: small winter flows can probably be pumped across the pipeline right-of-way during the installation of the crossing.

d) Ditch plugs: the pipeline ditch on either side of the stream crossing should be plugged or backfilled before the river crossing ditch is excavated, to assure that the stream does

not flow into the ditch or that silty ditch drainage does not get into the stream (Wilimovsky, 48:6407).

Some stream crossings will require blasting which gives rise to the concerns that are presented in ""Underwater Blasting".

Much of the material excavated from stream crossing ditches will be used as backfill but any material left over will need to be disposed of in a manner that does not interfere with the stream. This should not pose any problems where ditch spoil consists of unfrozen, granular material. The crossings of large rivers, for which summer construction is being proposed, have a potential spoil disposal problem. Excavation by dredge is being proposed for the crossings at Point Separation and further north, which involve primarily the excavation of sand and silt, which is to be discharged into the river channel downstream of the crossing (26:3113). This gives rise to two basic concerns: increasing the sediment load of the river and obstructing the river.

The Mackenzie River crossing near Fort Simpson will probably have to be excavated by dragline because the river bed material is likely to be too coarse for dredging. Draglines have much less flexibility than dredges indisposing of spoil and this obstruction of the river channel could be a concern. To what degree these large trenches across the Mackenzie are to be backfilled, and where the backfill is to come from, is not entirely clear from the evidence. Ditches excavated in sand and silt will tend to backfill naturally during the next spring flood but whether this would also happen in the Mackenzie River, upstream of Fort Simpson, seems doubtful.

Of all the stream related concerns, those related to the process of installing the pipe across streams in winter are probably the most critical principally because of the need to protect overwintering fish in certain streams and because effective control may be difficult to implement in the darkness and cold of winter.

Summer construction of crossings commonly will be of lesser concern because the work will take place at times when the rivers could naturally be subject to large scale disturbances caused by rain-induced summer floods. The disposal of spoil from dragline and dredge operation is amenable to a variety of solutions such as land disposal or barging to suitable dump sites (26:3113). The Agency need not accept the presently proposed, most econcmic

method of disposal into the river channel, downstream of the excavation, if further study should indicate that it is environmentally unacceptable.

5. The Company shall endeavour to have at least 2 years of periodic winter flow observations for all designated stream crossings prior to completion of final design.

6. Before completion of final design, the Company shall develop and test a construction technique (such as diversion or pumping) that permits pipe laying in the dry across any streams with winter flow up to 100 cfs.

7. All winter construction of crossings in watercourses containing overwintering fish or spawning areas less than 5 miles downstream is to be done in the dry by waiting for the stream to dry up, by diverting the stream, or by staging construction using cofferdams. Water flow, including intragravel movement, shall be maintained to any fish or egg overwintering areas and siltation shall be controlled to levels outlined in "Suspended Sediment Standards".

8. The pipe trench across the stream shall be backfilled with channel bed material.

9. As part of the planning for summer built crossings, the Company shall evaluate several alternate spoil disposal schemes from economic, technical and environmental points of view. At least three ranked schemes shall be submitted for approval in principle.

10. If spoil disposal into the river channel is proposed the Company must show that this does not increase the channel velocity to interfere with navigation or fish migration, and does not lead to increases in suspended sediment that are hazardous to fish (See "Suspended Sediment Standards").

11. Ditch plugs shall be left in place on both sides of stream crossings until the last possible minute, to assure that little or no ditch drainage flow can enter the stream and no streamflow can enter the ditch.

12. The interference with aquifers below winter-dry channels is to be minimized. In particular, the Company shall avoid plugging aquifers with silt or contaminating the groundwater

in any way. The construction time of crossings interfering with such aquifers is to be kept as short as possible.

13. Blasting should conform to the proposals listed in "Underwater Blasting".

SIZE AND CONSTRUCTION OF WORK PADS OR BERMS IN CHANNEL ZONES

DISCUSSION

At those crossings for which summer construction is proposed, the pipe will be assembled into major segments of several hundred feet length on a work pad on one side of the river and then pulled across the river. This operation can be done in stages, depending on the size of the work pad and on the width of the crossing (Dau, 33:4362). Depending on the valley cross section, this work pad may be built beside the channel zone on a flood plain (which is the preferred location) or it may have to be built in the channel zone itself where it might interfere with flows or might get washed away during a flood. If parts of a work pad are eroded by the river, serious siltation problems could arise, depending on the type of materials used in constructing the work pad.

Similar problems arise if parts of the channel zone were to be diked off with a cofferdam to permit pipe laying in the dry. By obstructing the channel zone one increases the velocity and erosive power of the flow in the remaining channel area. This can interfere directly with navigation or fish migration and it can also cause erosion of the channel bed and of the opposite bank (Stein, 122:18698).

14. Work pads and cofferdams will be designed to withstand the 1-in-25 year flood condition derived for the period of the year during which the pad or cofferdam will be in the channel zone.

15. The size of work pads or of the diked areas in the channel at any one time will be limited in such a manner that they do not interfere with fish migration or navigation and do not cause significant erosion at the 1-in-25 year flood condition.

16. At no time shall a work pad or a diked area occupy more than two fifths of the channel zone width.

17. Any borrow or spoil materials left in the river after removal of a work pad and any such material that is allowed to be eroded by the river shall not cause changes to the channel or bank morphology or to the river bed that are detrimental to fish or wildlife or to any other use of the watercourse.

SEDIMENTATION

DISCUSSION

Many of the fisheries concerns with a Mackenzie Valley gas pipeline relate to a concern about the introduction of sediment into streams in a harmful manner (Wilimovsky, 47:6153). The effects of suspended sediment on stream biota are unfortunately complex and by no means fully understood, so that it is difficult to draw up regulations that state in simple terms what is harmful and what is not. Whether a certain sediment concentration is harmful to a stream depends on where it occurs, when it occurs and what the water discharge happens to be at the time it occurs (Harlan, 82:12198); McCart, 85A:12774; Stein, 103:15723; Steigenberger, 103:15756).

One can say however, that introducing fine sediments (silt and sand) into a stream is likely to be harmful and certainly not beneficial, so that it should be avoided. A recent incident of significant, damaging sedimentation is discussed by Snow (126:19248-49).

As a rough guide one can assume that, if suspended sediment concentrations are kept within the natural range typical for the stream site, the time of the year, and the prevailing discharge, no harmful effects are likely to result. It is particularly important to ensure that the effect of discharge is not neglected. There is some evidence indicating that Arctic Gas believes that high sediment concentrations can be accepted in certain streams during summer and fall because they can occur naturally at that time (Minning, 78:11656). This neglects the fact that natural occurrences are associated with flood discharges which tend to wash the sediment down the stream channel rapidly and without significant deposition. Similar

sediment concentrations occurring at low flows might settle out on the stream bed in a damaging manner.

RECOMMENDATIONS

Many of the recommendations in this and other sections of this report dealing with River Crossings have reduction of sedimentation as a main objective and the same is true of the section on "Drainage and Erosion Control". Further recommendations relating to suspended sediment occur throughout the sections on "Fish Protection" and particularly under the heading "Suspended Sediment Standards".

RESTORATION OF RIVER BEDS AND BANKS

DISCUSSION

The construction of buried stream crossings involves the excavation of deep cuts (trenches) in the beds and banks of streams and the construction of work pads, coffer dams, winter roads, working surfaces and access ramps is also likely to result in some disturbance of beds and banks.

The pipe trench across stream channels is normally backfilled with "native" materials. As long as such backfill corresponds roughly to the original shape of the stream bed, the stream will re-grade the bed during the next flood. This involves little potential for significant long term impacts separate from the initial impacts resulting from construction work, which have been discussed previously. Fills placed on top of stream beds (work pads, ramps, etc.) naturally need to be removed but this too has little potential for long term impact as long as it is executed properly, keeping siltation and erosion within accpetable limits.

Restoration of the river banks has a greater potential for permanent impact. Poor restoration is unaesthetic, could lead to slides into the river with associated siltation, or could encourage the river to find a new course by breaking through the cut bank. Rivers associated with broad flood plains and river channels on deltas are normally contained by natural levêes. Such levêes tend to be very erosion resistant and are rarely breached by flood flows, although they may be frequently submerged. All Mackenzie Delta distributaries are associated

with such levées and it will be particularly important that they are properly restored at all pipeline crossings.

If the river bank material is ice-rich, cutting into it and leaving the cut exposed could initiate a lengthy cycle of thaw erosion (Adams, 46:6108-09). The Applicants appear to be well aware of these problems. Arctic Gas' methods of dealing with them are described by Clark (19A:2260) and, in more detail, by Hollingshead (21:2436). The bank cuts are to be backfilled with native material and blanketed with select backfill to prevent gullying and thaw erosion. Where the installation of the river crossing has reduced the resistance of the river bank against erosion, riprap or other bank erosion control measures (gabions, spurs, etc.) will be employed. The concerns related to such devices have been discussed under the heading "River Training Works" in "Crossings: Design Criteria". The second major concern related to the restoration of river banks arises from the fact that many are too steep to be restored to their original shape. As a consequence, the pipeline will frequently approach streams through a cut in the bank that will naturally tend to attract runoff water. Unless properly protected, the pipeline right-of-way will develop into one or several deeply scoured gullies and the pipe may become exposed. The Kotaneelee crossing of the Pointed Mountain pipeline provdes an excellent example of this sequence of event.

The erosion problem at steep river banks and valley walls is one of the most important and most frequently stated environmental concerns related to the present pipeline project. The solutions are well known but relatively expensive and therefore not always applied. They consist of an array of erosion control measures for steep slopes, such as granular backfills and blankets, insulation, revegetation, diversion of storm runoff away from the pipeline right-of-way, etc. (See "Drainage and Erosion Control"). The problems at river banks are not basically different from those on any other slope.

RECOMMENDATIONS

18. On the completion of in-stream pipeline construction, all stream beds are to be restored to their original shape using native or closely similar materials. On request, the Agency may relieve the Company from this requirement if he can show that the stream in question is sufficiently active to assure

restoration of the stream bed during the first freshet following construction, and if this does not interfere with the biological resources of the stream.

19. Stream banks are to be restored as close to their original shape as drainage and slope stability considerations permit. The restored banks are to be as erosion resistant as the natural banks immediately upstream and downstream from the crossing.

20. Restoration of river banks is to conform to the basic approach recommended in relation to location of <u>sag bends</u> in "Crossings: Design Criteria". Pipeline crossings should interfere as little as possible with normal lateral processes of the river.

CROSSINGS: MONITORING

GENERAL RECOMMENDATION

In view of the dynamic nature of rivers, ongoing monitoring of each pipe crossing and of the river channel adjacent to the crossing will be undertaken in order to record the seasonal and long term changes in the river bed and banks and the position of the pipe relative to them so as to be able to anticipate and plan for protection works or repairs.

DISCUSSION

Although river crossings are designed to withstand changes of the river and its channel, and to avoid disturbing the natural processes of evolution of the river, not all changes can be predicted accurately in advance. Prediction of the behaviour of arctic rivers is particularly uncertain because they involve processes not encountered elsewhere such as the formation of icings and thermal erosion of ice-rich soil on the banks. Although catastophic changes have to be dealt with as contingencies, slower changes can be monitored by repeated measurements in order to provide a basis for planning countermeasures. Such monitoring should be applied to changes that are seasonal or cyclical as well as those that are progressive. Parameters to be recorded include rate of channel shift, change in channel depth relative to position of the pipe (scour depth), ice jams and their effects, river icings and sub-channel flow in streams with low winter flow, changes in suspended sediment, and pipe movements caused by buoyancy, frost heave, etc.

RECOMMENDATIONS

1. A monitoring plan and schedule shall be submitted to the Agency for approval with the final design for each designated river crossing. Site-specific adjustments to the plan may be submitted up to the time of commissioning of the pipe. During operation of the pipeline, the appropriate governmental body may carry out or instruct the Company to carry out additional monitoring at any river crossing.

2. In general, the monitoring program should include the following components:

   (a) vertical stereoscopic and photo coverage at an appropriate scale once a year or more frequently for any crossing of a stream showing significant post channel migration or bank erosion;

   (b) channel soundings once a year for designated major stream crossings with mobile bed subject to scour: the soundings should extend over a channel reach of about 10 channel widths upstream and downstream from the pipeline;

   (c) soundings and other observations at crossings where major ice jams occur: as soon as possible after each ice jam has formed the crossing site should be sounded for scour holes and a procedure for detecting scour depth beneath ice jams should be developed;

   (d) flow measurements and water level records during winter at crossings where low water flow or groundwater is important to overwintering fish: this could include water yield of springs, piezometric measurements of groundwater, and observations on icings;

   (e) suspended sediment concentration (see "Suspended Sediment Standards");

   (f) position of the pipe relative to an established datum at crossings where the post bulb around the chilled pipe could encounter frost-susceptible soils.

3. On 31 August of each operating year the Company shall submit a report to the appropriate regulatory body summarizing the findings of the monitoring of stream crossings during the previous year.

4. After five years of operation of the pipeline, the Company may request reduction of the stream crossing monitoring program.

LOCATION OF FACILITIES

GENERAL RECOMMENDATION

The Company shall ensure minimal impact on river valleys, environmentally and biologically sensitive areas, scenic areas and areas important to native people through careful location of its compressor stations and associated facilities.

DISCUSSION

Evidence has been presented that the Applicants' proposed routes were largely determined on shortest distance, i.e. economic grounds. Major terrain barriers were considered at this first stage of selection, but once these had been avoided, suitable river crossing sites became major determinants of the route. Compressor stations were located at approximately 50 mile intervals at hydraulically optimum points based on pipe and station size and design gas volumes, then adjusted slightly in location as required by geotechnical considerations. The degree of flexibility in choosing sites is said to be very limited in order to achieve and/or maintain hydraulic balance and throughput efficiency.

Compressor stations are the focal points of activity and construction during the building and operation of the pipeline -- hence the term "facilities complex". Airstrips, helipads, wharves, stockpiles, roads (permanent and temporary), borrow pits and permanent housing are all located in the vicinity of compressor stations, and some compressor station pads will also be used as the sites of the large construction camps.

In the total view, the trunk gas line is a dynamic linear element across the northern landscape with nodes of great activity at 50 mile intervals. At a smaller scale, however, these focal points are not small nodes of activity centred on the compressor stations, but are themselves linear: they sprawl from wharf sites on the Mackenzie River to stockpile sites on the right-of-way and to helipads, airfields and borrow pits. They may include several miles of road and tens of square miles of land. Also, they generally lie at right angles to the pipeline itself and the Mackenzie Highway right-of-way which may be crossed.

Moreoever, these nodes of activity exist not only for the construction phase, but will persist at a lower level of activity throughout the lifetime of the pipeline. During looping of the

line, this lower level of operation will be punctuated by sustained bursts of activity centred at, but not restricted to, compressor stations, which will approximate the level during original construction.

It is these factors -- accumulative level of activity, amount and distribution of land involved and length of time -- which make the location of compressor stations so vital. It is particularly important that their location avoid, as far as possible, environmentally or biologically sensitive areas, and areas with a high aesthetic value.

Valleys and valley walls are a case in point. Valleys crossed by the pipeline constitute only a small proportion of the total landscape, but they have disproportionately high land-use, environmental, aesthetic and recreational values. They encompass essential fish, aquatic mammal and moose habitat; the vegetation in them is more varied and lush than elsewhere, complementing the scenic superiority which they exhibit over rather monotanous inter-stream uplands. Valleys have always been and still are the preferred travel routes for native peoples and are the sites of many historic and archaeological remains. (PAAG, pp. 219-22). In fact, valleys are the counter part of facilities complexes. They are the focal points of ecosystem (in the broadest sense) acitivity, whether it be geological, hydrological, biological, cultural or economic.

Valleys are just as important to the ecosystems crossed by the pipeline as the facilities complexes are to the pipeline itself and warrant equal consideration.

It would seem that neither Applicant has considered the above adequately in the siting of its compressor stations (e.g. Exhibit 88). However the following factors suggest a greater degree of flexibility in the future siting of compressor stations than has been admitted by the Applicants:

(a) tentative state of the route;

(b) indecision on the part of the Applicants as to final turbine type;

(c) range in horsepower available at stations by virtue of what is commercially available can be feasibly modified;

(d) the excess horsepower built into the design of every station;

(e) lack of precise elevations for the pipeline profile (G. Perrault, pers. comm., and and NEB transcripts about July 26, 1976.);

(f) substitution of looping for compressor horsepower in maintaining throughout; and

(g) social Guideline No. 4 which states: "In addition, where the pipeline construction is planned to be located in proximity to a settlement...particularly a native settlement or localized area subject to intensive use, then the location of construction camps, associated activities and the detailed siting of the pipeline will be decided by government after consultation with the Applicant, and the settlement council, or local government body, or the native organization," (1972 Pipeline Guidelines).

RECOMMENDATIONS: THE COMPANY

1. The final location of compressor stations shall reflect the joint impact of the following concerns on major valleys, environmentally and biologically sensitive areas, scenic areas and areas important to native people:

   (a) the cumulative and synergistic effect of all facilities associated with the compressor stations; and

   (b) the operational lifetime of facilities and activities.

2. The Company shall comply with Social Guideline No. 4, "1972 Pipeline Guidelines".

3. As a general guide, the Company shall not locate facilities complexes within three miles of a major valley edge. "Major valley" is to be defined by the Agency, but would not be restricted to perennial streams since major streams, particularly on the North Slope freeze to the bottom in winter.

4. In all cases where the Company hopes to have this constraint waived, it shall submit in a form that facilitates checking and verification, detailed plans and comparison of the technical, capital and operating costs, and the environmental and social impact differences for an acceptable site (outside the three mile limit) as well as its proposed alternative. In particular, data and printouts related to the hydraulics and economics of compressor station spacing shall be submitted in a form readily verifiable by the Agency.

RECOMMENDATIONS: THE GOVERNMENT

5. The Agency should critically review the Company's compressor station locations bearing in mind the 1972 Pipeline Guidelines and the other concerns outlined above.

SOURCES OF INFORMATION

As noted in the text.

CAMPS, WHARVES AND STOCKPILE SITES

GENERAL RECOMMENDATION

The Company shall design and locate all wharves, stockpile sites and construction camps to suit the immediate and long term aspirations of the local people and to minimize adverse environmental effects.

The Agency should ensure that the facilities built for the pipeline construction complement, as much as possible, the ongoing planning process in the Mackenzie Valley and Northern Yukon.

DISCUSSION

The Mackenzie River system and the Artic coastline are to be utilized as main supply routes for the transportation of heavy equipment and supplies necessary for the construction of a gas pipeline. Where required along these waterways, wharves, either existing or constructed for pipeline purposes, will be utilized to off load equipment and supplies. These will be stored either at the wharf site or further in land at stockpile sites until the winter construction season.

In total, Arctic Gas plans to move about 1.5 million tons over a three year period. Foothills plans to move 1.03 million tons. The scale of the transhipment operation at a particular wharf/stockpile site is exemplified by the breakdown of materials to be moved through a typical wharf/stockpile site (CAGPL):

(a) fuels: 2.6 million gallons
(b) pipe: 45,000 tons
(c) explosives: 500 tons
(d) miscellaneous: camp facilities, heavy equipment etc. 9,500 tons (approximately).

The approach of both Applicants is similar. During the ice free shipping season barges will handle the transportation of pipe fuels, lubricants, heavy equipment, modular campsite components, and other necessary equipment and supplies. The wharves/stockpile sites will be utilized throughout the construction phase of the project and, in some cases, during the operational and maintenance phases. Construction camps will be removed after completion of the construction work.

Both Applicants propose stockpile sites on both sides of major river crossings and both plan campsites of up to 800 men at the stockpile sites, transhipment sites and the compressor station sites.

Arctic Gas is proposing approximately 20 wharf sites for its prime route. They plan to utilize Dew Line sites along the Yukon Arctic Coast, temporary wharf facilities in the Delta and mainly permanent wharf facilities on the Mackenzie. Stockpile sites will be either located at the wharf site or at the compressor station site.

Foothills plans approximately 15 wharf sites in the Delta and along the Mackenzie River. Their stockpile sites will be adjacent to the wharf sites.

Both the Applicants plan for the location and design of wharves and stockpile sites (and hence some camps) were founded on basic assumptions that are now, in hindsite, questionable. The assumptions about the continuation of the Mackenzie Highway, the capacity of the Dempster Highway, the useability of the Simpson to Inuvik winter road, the ability of helicopters to perform as required under adverse winter conditions, the availability of community wharf sites, airstrips etc. are all variables that have been assumed fixed by the Applicants. Also, of particular concern is the proposal to establish a major transhipment point at Axe Point. This proposal must receive the most careful scrutiny by government to assess the short and long range ramifications for the existing adjacent communities, the immediate and long range transportation infrastructure and the overall planning in region.

The specific location of the camps and wharves/stockpile sites (which is determined in part by the above assumptions) is of concern when considering both the environmental and socio-economic impact of the pipeline project. In many instances, the location scheduling and method of operation of these facilities will govern the impact of the project.

Inadequate consultation, planning and site specific studies prior to the final site selection and inadequate control during operation could result in substantial impacts on northern peoples, northern business, existing and future land use patterns (traditional and others), fish and wildlife resources, archaeological sites, etc. Existing communities may, in some

cases, benefit from new or improved facilities that complement their infrastructure. This could be particularly applicable to major staging areas such as Bay River, Fort Simpson, Norman Wells and Inuvik. However, some communities may not want anything to do with the camps, wharves/stockpile sites associated with the project. Recognition of the individual communities decisions must be accounted for during the site selection and design process.

The specific design of the on-site facilities, the handling and storage of materials, the regulation of human activities, and scheduling of activities during site preparation and pipeline construction are also of major concern.

Locating sites on unstable terrain, ground water recharge areas, or in areas subject to water inundation (flooding and storm surges), could result in terrain disturbance both in the short and long term, and could increase the frequency or risk of accidental chemical spills.

Destruction of fish and wildlife habitat, due to the presence of men and equipment, may cause disturbance during the critical life cycle phases of animals. The potential of fuels or other toxic chemicals entering a watercourse from a wharf/stockpile site which may have adverse effects on the inhabitants and users of this resource must be acknowledged as a major concern (see "Spill Prevention and Control").

Arctic Gas estimates that a typical wharf and associated stockpile site (with camp) will occupy approximately 25 acres. A stockpile site at a compressor station (with camp) will disturb approximately the same acreage. In total this represents a relatively small area of terrain and wildlife habitat disturbance. The degree of the impact will depend on the planning and environmental assessment of each site. The construction and operation of the camps, wharves/stockpile sites could have severe long term impact on the fish population of the area. Continuous sediment and toxic chemical inputs into the aquatic system could directly destroy fish populations or alter behavioral patterns. Proper construction methods and fuel handling safeguards will do much to mitigate any serious impacts (see "Spill Prevention and Control").

Finally, the selection of wharf sites must be particularly cognizant of archeological evidence. Many of the best sites for

pipeline purposes may also have been national campsites for the aboriginal inhabitants of the area. These sites represent an irreplacable heritage for all Canadians, in particular for the decendents of the aboriginal peoples. As such, every effort should be taken to safeguard and document the resource.

RECOMMENDATIONS: THE COMPANY

Overall Plan

1. Prior to commencement of final design the Company shall submit for Agency approval camps, wharves and stockpile sites for all documenting:

   (a) The location of all such facilities (in map form) relative to the pipeline right-of-way, the Mackenzie River, existing communities and existing or proposed (by others) rights-of-way such as the Mackenzie Highway, existing wharf sites, winter roads etc.

   (b) The general work schedules for each facility. Each wharf site and stockpile site shall be designated with alternative sites that would be acceptable to the Company if the Agency feels that the prime site is undesirable.

   (c) The design standards to be applied to the wharves, stockpile sites.

   (d) The total estimated capital cost and the annual operation and maintenance cost of each permanent and temporary wharf. Upon request, a net present value analysis shall be prepared for each proposed new wharf and an incremental operating and maintenance cost increase analysis shall be prepared for any existing facility that is proposed for upgrading. A cost-benefit analysis of specified alternatives to the Company's plans shall also be prepared if requested by the Agency.

   (e) The rationale that was used in determining the design standard and location for each particular work and in particular, the rationale used in the Company's decision to:

(i) build new wharves and stockpile sites rather than use existing facilities vice versa; and

(ii) use temporary rather than permanent wharves and stockpile sites or vice versa.

(f) The general borrow areas that will be used to construct the works.

(g) All assumptions that the Company has made with respect to the availability of existing wharves, stockpile and other transport facilities, and the approximate volume of project related traffic that such facilities will sustain over the life of construction (broken down into monthly winter and summer periods) and during pipeline operation (broken down on a quarterly basis).

(h) All assumptions the Company has made with respect to work by parties not associated with the pipeline company (i.e. extensions to the Mackenzie Highway, expansion of existing stockpile, wharves etc. works constructed by the gas producers etc.).

Comment: The Overall Plan will be a key document in the Agency's assessment of the logistics of the project and the short and long term implications for ongoing government programs and funding. The Company may be asked to modify its plans to better suit non-project related plans and the specific concerns of local people. Therefore, it is important that the Company receive the input by the Agency at this overview stage before major final design is committed.

Site-Specific Application

2. The site-specific application shall include:

(a) a map indicating the exact location of all proposed wharves, stockpile sites and camps with supporting socio-economic and environmental information used in location;

(b) the detailed schedules of construction and use;

(c) the maximum anticipation of traffic volumes and camp populations during various pipeline construction periods and during pipeline operation;

(d) detailed construction drawings and specifications;

(e) the exact location of borrow material sources and haul routes along with the quantities and quality of such material (see Borrow Operations);

(f) the capital, operation and maintenance costs (for new or upgraded facilities) that will be borne by the Company and that the Company anticipates will have to be borne by others; and

(h) post construction plans designating facilities required for operation and maintenance, the method of payment for ongoing use, the plans for facilities that are no longer required and the overall abandonment plans at the end of the useful life of the project or facility.

Location and Design Considerations

3. The location and design of all camps, wharves and stockpile sites shall account for the site specific features of the local environment including:

(a) geotechnical considerations (permafrost);

(b) drainage and erosion control (particularly for facilities located in the Delta);

(c) wildlife habitat and migration;

(d) fish habitat and migration patterns;

(e) land use patterns;

(f) human settlements and camps; and

(g) archaelogical resources.

4. Wharf and stockpile sites shall be located away from the confluence of rivers and river mouths unless otherwise

specifically approved by the Agency. The location and design of stockpile sites shall be cognizant of river flood stages and storm surges.

Comment: The protection of stockpile sites - particularly those with bulk fuel storage - from the flash floods and surges is particularly important in the Delta and along the Arctic Coast.

5. Wharf and stockpile sites shall be located at sites that provide the best possible opportunity to implement effective contigency plans in the event of an oil spill or similar event. Reaches of rivers with fast water, limited access, important biological or social features etc. should be avoided.

6. All fuel product piping systems at wharves, camps and stockpile sites shall be located above ground.

7. All wharves, stockpile sites and camps shall be equipped with spill prevention, control and clean up devices. (see "Spill Prevention and Control")

8. The location of camps, wharves and stockpile sites shall conform to the proposals for protecting raptors and waterfowl presented in the section on "Birds".

9. Camps shall be located preferentially at stockpile sites, wharves or compressor station sites. Applications for camps located outside these areas shall be supported by explaining why such sites are undesirable.

10. The camps built or used by the Company shall be self sufficient with their own support facilities such as power supply, water supply, sewage treatment and disposal, first aid station, recreation etc.

11. All designs, navigation aids etc. for wharves shall meet the requirements of the Ministry of Transport for the nature of the particular facility and the traffic types and volumes anticipated.

12. Wherever possible dead anchors for wharf sites should be pile driven or drilled rather than excavated and back filled. Approaches to the beach from the upper plateaus should be by fill rather than cutting through the embankment.

Construction and Maintenance

13. The cost of all construction operation and maintenance associated with new wharves and stockpile sites shall be borne entirely by the Company.

14. The cost of construction, operation and maintenance associated with the expansion or upgrading of existing wharves and stockpile sites shall be assumed by the Company unless otherwise previously agreed to by the government.

15. Upon abandonment, the facilities shall be removed and the area restored in a manner approved by the Agency.

Access and Operation

16. All camps, wharves and stockpile sites shall be located as detailed in the approved design. No such facilities should be established with field without Agency approval.

17. Where the Company uses existing wharves and stockpile sites that use shall be planned and ammended on a daily and seasonal basis so that priority is given to the ongoing use by others.

18. Access to facilities built by the Company for its own use shall be limited to Company or government personnel. The Company should take all reasonable steps to discourage access by local people and any others not employed by the Company, the Agency or any of their contractors and subcontractors who are actively engaged on the project. In particular the Company should limit access to construction camps to only those persons associated by employment on that portion of the work.

19. All persons using camp facilities shall be limited to the jobsite and campsite areas. The Company should use the full extent of its legal and corporate ability to achieve this end.

Comment: Workers on the project whether they be employed by the Company, the government or any of their contractors must be discouraged by every possible means from disrupting the local communities. Many of the construction camps will have

populations equal to or greater than the adjacent communities. Since there is a very real possibility for substantial social upset the control of the field work force must receive the highest priority in the Company. Violation of the controls should subject the offender to most severe penalties including dismissal. The Company should include terms on employee control in all its contracts and all its employment policies.

RECOMMENDATIONS: THE GOVERNMENT

Existing and Proposed Facilities

20. Before granting a right-of-way permit the government should establish a clear policy regarding the Company's use of existing wharves and stockpile sites and the limits to the Company's prerogatives in establishing new facilities. Such a policy statement should indicate:

(a) the exact nature, location and standard of all works to be undertaken by government or crown corporations;

(b) a definitive timetable for all such works;

(c) the acceptable location, duration of use etc. of new facilities that might be required by the Company (i.e. Axe Point); and

(d) cost sharing arrangements, if any (capital, operation and maintenance).

Comment: The government policy should reflect the desires of the communities along the Mackenzie River system. Where existing community facilities are to be used or upgraded, there should be a very clear capital and maintenance cost sharing agreements. The establishment of new facilities outside existing centres should be carefully controlled to maintain the viability of existing facilities and avoid long range redundancies of facilities.

21. The Agency should assess the Company's requirements and plans for camps, wharves and stockpile sites with the view of integrating the Company's requirements with ongoing and long range government and community planning in the Mackenzie Valley. The Company's facilities should be made to

complement the aspirations within existing communities and the ongoing planning process.

SOURCES OF INFORMATION

1. <u>Transcripts, Exhibits, Basic Documents</u>

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FH	Bouckhout, C.W. (87:13090-92; 100:15346-50); Ellwood, J. (19:1855-57); Fawcett, M.A. (59:8351; 60:8565); Finney, G. (100:15200); Hayden, W. (100:15314); Hushion, D.H. (68:10045, 10109); Mirosh, E.A. (59:8425-26; 60:8567; 67:10013-14, 10022-24; 68:10092-93, 10110-13)
CARC	Millen, J.M. (103:15789-90; 104:15965; 105:15992-96, 16122-24); Steigenberger, L.W. (103:15763)
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Private	Deller, T. (C-25:2533-36); Hammond, C. (C-25:2518); McMeekin, R. (C-4:227-28); Orbell, R. (C-32:3034-35)

CAGPL Application (as amended to 8 March 1976) Sections: 6.4.4., Wharves; 6.4.5., Camps; 8.b.1.4.6., Fuel storage, water supply, waste treatment and disposal; 9. Connecting pipeline facilities.

Responses; Question 12, pp. 12-1 - 12-7.

PAAG Report

2. Reports

Lombard North Group Ltd.
1976 Facility site catalogue: Site assessment; Biological field program report: 1975; Vol. II (for Foothills).

ROADS, AIRSTRIPS AND HELICOPTER PADS

GENERAL RECOMMENDATIONS

The Company shall design all roads, airstrips and helicopter pads in accordance with government's technical and environmental standards and shall locate all such facilities so that they complement the long range planning needs of the government and the wishes of the northern communities. In locations where the Company plans to upgrade or otherwise utilize existing facilities, it shall do so without interfering with the ongoing use by others. In all cases the cost of building, upgrading, operating and maintaining roads, airports and helipads shall be borne by the Company unless otherwise prescribed by the government.

The government should make a clear policy statement on the availability of existing and proposed roads (e.g. the Mackenzie Highway), airstrips and helipads for the pipeline project during construction and operation.

DISCUSSION

Both Applicants plan to build a multitude of roads, airstrips and/or helipads for construction logistics support and for routine operation and maintenance of the pipeline. Roads will be built to serve wharf and stockpile areas, borrow pits, airstrips, helipads and compressor stations. Airstrips and helipads will be built at compressor stations and main staging areas to transport men and equipment to and from the sites.

Arctic Gas will rely mainly on fixed wing aircraft for construction and operation purposes by building approximately fifteen STOL airstrips (2,900 feet), five major airstrips (6,000 feet) and by upgrading one existing airstrip. Foothills plans to rely on helicopters with backup support from (winter) roads.

The logistics plans of both Applicants are based on a number of assumptions about the availability of the Dempster Highway, the extent of completion of the Mackenzie Highway, the use of existing airstrips and the construction of logistics support facilities by the gas producers. Over the course of the hearings it has become apparent that many of these assumptions may not be valid.

The state of completion of the Mackenzie Highway is a key variable in the plans for roads, airstrips and helicopter pads on the pipeline project. While both Applicants assert that a highway is not necessary for construction of the pipeline they do concede that it would be an asset during construction and particularly during operation. It is reasonable to conclude that pressure will be placed on government to continue the Mackenzie Highway construction program. While this may have some merit for the project, the government must be cognizant of the reservations expressed by the indigenous population and the views advanced by expert environmental witnesses. Both groups agree that the access provided by the highway would pose an environmental and social threat far greater than that posed by a pipeline.

Despite the statements in the "1972 Pipeline Guidelines", the evidence indicates that the highway, and the river transportation system, not the pipeline, are the determinant factors in a Mackenzie Valley corridor. In any event, the government must move with the utmost caution if it decides to continue construction on the Mackenzie Highway. The burden of proof of synergistic social and environmental effects must rest on the proponent of the highway.

Other aspects of the Applicants' planning cause some concern. For example, where they plan to use or upgrade existing roads or airstrips, it is not clear who will bear the cost of increased operation and maintenance costs either during the Company's use or afterward when the (expanded) facility is left to others to maintain. Evidence from Alaska has indicated that maintenance costs on state highways has been astronomical because of the increase in use by pipeline related activities. In some places highways are closed for extended periods daily so they can be maintained. A similar situation could occur in the Yukon and NWT where the roads and airstrips will be very heavily used. A clear government policy and definitive maintenance plans will be necessary before any pipeline construction begins.

The plans of Foothills Pipe Lines to rely on helicopters rather than fixed wing aircraft for logistics support give rise to profound concerns. The limited capacity of helicopters, their very restricted capabilities under icing conditions and operating constraints posed by IFR conditions make it apparent that other support mechanisms will have to be developed for both pipeline construction and operation in the North. Also, there is higher potential for disturbance of wildlife by helicopters than for

fixed wing aircraft. These factors, the unsuitability of the Simpson to Inuvik winter road for pipeline support and the general lack of roads make Foothills' present logistics plans somewhat questionable.

Finally, the evidence indicates that the location of roads, airstrips and helipads (and hence wharves and stockpile sites) is more flexible than the location of the pipeline compressor station sites which they often serve. Therefore, one way that the environmental and social effect of the project can be altered is by relocating the roads, airstrips, helipads and other support facilities (wharves, stockpile sites, etc.). In this way spin-off community effects can be tailored to ongoing government planning and terrain and wildlife disturbance can be controlled.

RECOMMENDATIONS: THE COMPANY

Overall Plan

1. Prior to commencement of final design the Company shall submit for government approval an Overall Plan for all roads, airstrips and helipads documenting:

   (a) The location of all roads, airstrips and helipads (in map form) relative to the pipeline right-of-way, the Mackenzie River, existing communities and existing or proposed (by others) facilities such as the Mackenzie Highway, land lines, winter roads, borrow pits and wharves. Each airstrip and helipad location shall be designated with possible alternative sites that would be acceptable to the Company if the Agency feels that the prime site is undesirable.

   (b) The design standards to be applied to the various parts of the works including stream and river crossings.

   (c) Estimates of the capital cost and the annual operation and maintenance cost of each airstrip, helipad and each segment of continuous road of a specified design standard. A net present value analysis shall be prepared for each proposed new airstrip and an incremental operating and maintenance cost increase analysis shall be prepared for any existing facility that is proposed for upgrading.

(d) The rationale that was used in determining the design standard and location for each particular work and in particular, the rationale used in the Company's decision to:

(i) use gravel instead of snow roads,

(ii) build new airports or helipads rather than use existing facilities and vice versa,

(iii) use airstrips rather than helipads or vice versa and

(iv) use new rather than existing rights-of-way

(e) The general borrow areas that will be used to construct the works.

(f) All assumptions that the Company has made with respect to the availability of existing roads, airports and helipads and the approximate volume of project related traffic that such facilities will sustain over the life of construction (broken down into monthly winter and summer periods) and during pipeline operation (broken down on a quarterly basis).

(g) All assumptions the Company has made with respect tc proposed road, airstrip or helipad built by parties not associated with the pipeline company (e.g. extensions to the Mackenzie Highway, works constructed by the gas producers etc.).

Comment: The Overall Plan for roads, airstrips and helipads will be a key document in the government's assessment of the logistics of the project and the short and long term implications for ongoing government programs and funding. The Company may be asked to modify its plans to better suit non-project related plans and projects. For example, the government may decide that a road or airstrip proposed by the Company could serve other interests if it were relocated or redesigned in a certain fashion.

Site-Specific Application

2. The site-specific application shall include:

(a) a map indicating the exact location of all proposed roads, airstrips and helipads with supporting socio-economic and environmental information used in location;

(b) the schedule of construction and duration of use;

(c) the maximum anticipated traffic volumes during various pipeline construction periods and during pipeline operation;

(d) detailed construction drawings and specifications showing compliance with government design standards for roads, airstrips and helipads;

(e) the exact location of borrow material sources and haul routes along with the quantities and quality of such material (see "Borrow Operations");

(f) the use of insulation or other non-granular materials in the embankment;

(g) all thermal analyses and geotechnical information used in design;

(h) the location and size of all fill stockpiles designated for maintenance or other uses;

(i) all fish and wildlife information used in location and design;

(j) the designs and design criteria employed to facilitate the passage of ungulates and fish;

(k) the methods and needs for maintenance including snow removal, snow fencing, grading etc.;

(l) the capital, operation and maintenance costs that will be borne by the Company and that the Company anticipates will have to be borne by others; and

(m) post construction plans designating facilities required for operation and maintenance, the method of payment for ongoing use, the plans for facilities that are no longer required and the overall abandonment plans at the end of the useful life of the project or facility.

3. Each road, airstrip or helipad that is proposed for the Northern Yukon or in the Mackenzie Delta shall be the subject of a separate application for a separate notice to proceed.

Comment: The construction of any support facilities in the Northern Yukon or in the Delta which will outlast the construction of the pipeline will be actively discouraged. Permanent roads along the right-of-way on the North Slope will be prohibited. The Company must develop logistics plans that will keep to an absolute minimum the number of gravel roads, airports and helipads by making maximum use of snow roads and similar temporary access facilities or alternative means of logistics support.

4. Where the Company plans to use permanent or snow road alignments that parallel substantial parts of the proposed Mackenzie Highway, detailed capital and maintenance cost estimates of the road work shall be included in the application.

5. The location and design of all roads, airstrips and helipads shall account for the site-specific features of the local environment including:

(a) geotechnical considerations (permafrost);

(b) drainage and erosion control

(c) wildlife habitat and migrations;

(d) fish habitat and migration patterns;

(e) land and water use;

(f) human settlements and camps; and

(g) archaeological resources.

6. Unless otherwise specifically approved by the Agency, all roads, airstrips and helipads shall be located at least 300 feet from any river, lake or stream.

7. The location of roads, airstrips and helipads shall conform to the proposals for protecting raptors, waterfowl and mammals presented in "Birds" and "Terrestrial and Aquatic Mammals".

Location and Design Considerations

8. All roads, airports and helipads shall be built to comply with government standards. In particular, the minimum standard for roads shall be as designated for "Airport Roads" as specified in the Northern Roads Classification System Standards unless specifically otherwise approved by the government. Furthermore, the design and construction shall comply with the standards described in the Fisheries Service guidelines for highway construction in the Northwest Territories.

9. If the Company decides that any shoo-fly roads are to be permanent for operation and maintenance reasons, the shoo-fly roads shall be designated as permanent and shall be designed as all other permanent roads with due attention in the design to drainage etc.

10. All designs, navigation aids etc. for airstrip or helipad facilities shall meet the requirements of the Ministry of Transport for the nature of the particular facility and the traffic types and volumes anticipated.

Construction and Maintenance

11. The cost of all construction, operation and maintenance associated with new roads, airports and helipads shall be borne entirely by the Company.

12. The cost of construction, operation and maintenence associated with the expansion or upgrading of existing roads, airports and helipads shall be assumed by the Company unless otherwise previously agreed to by the government.

13. The Company shall have archaeological expertise on-site during construction in all areas determined to have archaeological significance.

Access and Use

14. During construction the Company shall limit the use of all new airports, roads and helipads built for the project to vehicles and aircraft associated with the project except for emergency situations that pose a threat to human life.

15. After construction and during pipeline operation the Company shall, at the request of the government, limit access to those roads, airstrips and helipads that are required for operation purposes and shall remove or otherwise obstruct access in a manner approved by the government to facilities that are not required.

Comment: Recommendations 14 and 15 are designed to assist in protecting fish and wildlife and should be viewed in conjunction with the sections on birds, mammals and fish.

16. Vehicles on the project shall be operated only on the designated rights-of-way or on the lands leased or owned by the Company unless otherwise approved by the government.

17. Where the Company uses existing roads, airports or helipads, it shall assure the availability of the facility for the ongoing needs of others. The Company shall plan and amend its daily and seasonal operations so that they do not prejudice normal use or access by others.

18. All roads, airports and helipads shall be located and operated only as detailed in the approved design. No field or other approvals shall be given for any works outside the areas specifically designated in the application.

Comment: Traffic scheduling on roads and at airports and helipads should account for the movements of mammals (caribou) and birds (waterfowl). Avoidance or restricted traffic movements should be practised.

RECOMMENDATIONS: THE GOVERNMENT

Existing and Proposed Facilities

19. Before granting a right-of-way permit the government should make a clear statement on what policy will be followed with respect to the Company's use of existing roads, airstrips and helipads. Such a policy statement should indicate:

    (a) the exact nature, location and standard of all works to be undertaken by government or crown corporations;

    (b) a definitive timetable for all such works; and

    (c) the acceptable locations for major new facilities that might be required by the Company, and cost sharing arrangements, if any (capital, operation and maintenance).

Comment: The Applicants before the Inquiry have made a number of assumptions on the use of existing airports and roads (e.g. the Dempster Highway, community airstrips). They have also made definite plans based on the availability of facilities such as the Mackenzie Highway which are not yet complete. It is imperative that the government make its position on these matters very clear at the outset so the Company and the government itself can proceed in a clearly understood well planned manner.

20. The government should reassess its policy and plans for a Mackenzie Highway considering the concerns of the indigenous peoples, the concerns of wildlife experts, the reality of the pipeline project's needs and the needs of such a highway for future development in the Mackenzie Valley.

Comment: Both Applicants before the Inquiry have stated clearly that although a Mackenzie Highway would be of some assistance in building and operating the pipeline, it is not essential. Other witnesses, principally from Alaska, have expressed the view that an all weather road is essential for pipeline construction and operation. People testifying in the communities have expressed great apprehension about the effects of a highway. Various expert witnesses at the formal hearings have indicated that the environmental/social impact of a highway would be many orders of magnitude greater than that of a pipeline.

21. The government should assess the Company's requirements and plans for roads, airstrips and helipads with the view of integrating the Company's requirements with ongoing and long range government and community planning in the Mackenzie Valley and Northern Yukon. The Company's facilities should be made to complement the aspirations of existing communities and the ongoing planning process.

Access

22. The government should, after reviewing the Company's preliminary design, make a detailed and broad transportation study in order to optimize the long range benefits of all road, airstrip and helipad works to be undertaken by the Company. Such a study should account for the desirability to limit access to part of the area traversed by the pipeline and should define ways of access limitation achievable through:

    (a) the Company's design and location and abandonment of roads, airports and helipads, and

    (b) the government's policy to use Company facilities (including roads) during and after the pipeline construction and operating periods.

23. The government should make an unequivocal policy that there will be no permanent road construction along or adjacent to the right-of-way in the Northern Yukon NO MATTER WHAT TYPE OF DIFFICULTY THE PIPELINE CONSTRUCTION OR OPERATION ENCOUNTERS. The Company should therefore be advised that this section of the line would have to be abandoned rather than permit an all-weather road to be built.

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1. Transcripts, Exhibits, Basic Documents

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CARC	Lent, P.C. (110:16780-81, 16823-27, 16865-67, 16873); Millen, J.M. (104:15965-66); Parker, W. (54:7517-54; 75:11026-34; 76:11187-98, 11282-96)' Stein, J.N. (103:15807-09); Walker, C.E. (104:15968-70, 105:15978-81); Weedon, R. (75:11050-60)
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Exhibit 493: CAGPL. 1976. Plan refinements

CAGPL Application (as amended to 8 March 1976) 8.b.1.4, 8.b.1.5

2. Reports

Dryden, R.L., and J.N. Stein
1975 Guidelines for the protection of the fish resources of the Northwest Territories during highway construction and operation; DOE, Fisheries and Marine Service, Tech. Rept. CEN/T-75-1 (Exhibit 376).

Poston, H.
1973 Waterfowl populations observed along the proposed gas pipeline route, Richards Island to NWT-Alberta border; CWS. 437; a;a

COMPRESSOR STATION NOISE

GENERAL RECOMMENDATION

The Company shall take all possible measures consistent with reasonable technical and economic constraints to minimize the noise of operating compressor stations.

DISCUSSION

Background noise at compressor stations under the Applicants' proposals will be so intense that personnel inside the buildings will require ear muffs or earplugs while, outside at the fenceline, the noise level will still be in the 60-68 dBA range. This noise could range from annoying to harmful for unprotected personnel or those working outside the buildings, could certainly be annoying to local people at some locations where their activities bring them near stations, and finally may be disturbing to ammmals and birds as to prevent their use of an area around a station.

Proposed compressor station noise levels will mask or intrude upon background noise over substantial areas since the sound level to which noise must be reduced before it is muffled by background noise is 15dBA less than the background sound level of the setting (Dailey and Redman, 1975 p.16).

Assuming a reading of 53dBA 1000 feet from the compressor station fence line (CAGPL, Response to NEB Deficiency Letter No.4, Qu. 13) then at 16,000 feet or 3 miles the noise has only attenuated by the law of inverse square to 29dBA and to 23dBA at 6 miles.

In a treeless tundra environment, at least in winter, one might expect natural attenuation and background noise to be less than 30 dBA found in an alpine meadow with scattered tall conifers (Dailey and Redman, 1975). However, assuming a Mackenzie Valley-North Slope background noise level under low wind (not calm) conditions as 30 and 35dBA for open and forested landscapes respectively, compressor station noise could be intrusive down to 15 and 20dBA levels, that is at distances of up to 10 miles. Topographic, terrain, vegetative and meteorological conditions may of course diminish or increase to the attenuation which otherwise is basically a reduction of 6dBA for each doubling of distance from a point source.

Arctic Gas has presented a range of noise levels for existing or available equipment with conventional silencing and said that, "...in sensitive areas, additional noise reduction measures according to the best feasible technology will be used...." (14.d.N 2.2.4). Foothills has made a similar statement (Beer 63:9006).

This wording is implicit recognition that noise attenuation beyond "conventional silencing" is expected at least in some places. Furthermore Koskimaki indicated (31:3935) that equipment suppliers furnish the sound power (noise) levels available from different degrees of silencing and then the Company selects the level according to the situation at the proposed station. This makes it unclear just what degree of silencing is "conventional". The Tables in the Canadian Arctic Gas Application and in the reply to the NEB Deficiency Letter refer to "conventional silencing", but obviously if "conventional" means "off-the-shelf" equipment then Koskimaki's evidence indicates there is a choice <u>on the shelf</u>. He goes on to say (31:3936-37) that noise levels are calculated for "normal silencing" and for "maximum silencing" techniques that could be available. He says that the latter could reduce fence line levels from 59-67 to around 50 or 53 dBA.

RECOMMENDATIONS: THE COMPANY

1. Normal operating noise levels 1,500 feet from the centre of the compressor station shall not exceed 50 dBA under calm conditions at all seasons of the year.

<u>Comment</u>: Dr. Gunn, Ornithological Consultant to Arctic Gas, has recommended that the average sound level be limited to 50 dBA at 1,000 feet from the compressor station. Arctic Gas has calculated noise levels of 50-56 dBA 1,000 feet from the fence line for 30,000 and 55,000 HP stations with refrigeration (CAGPL, Response to NEB Deficiency Letter No. 4, Qu. 13). Furthermore, as noted in the Discussion, Koskimaki says that by going from conventional to maximum silencing techniques, <u>reduction at the compressor station fence line</u> from 59-67 to "around 50 or 53" is possible (31:3936-37).

It seems that 50 dBA at 1,500 feet from the station centre, which should be somewhat more than 1,000 feet from the fence line, is a reasonable requirement for the average station and is, by admission of the Applicant's own witnesses, an attainable objective with near conventional equipment.

The centre of the compressor station means the geographic centre of the compressor station pad at the time of construction. This choice avoids the problems inherent in using as a base, a fence line which may not be permanent and which is unlikely to be equidistant on all four sides from the first or subsequent compressor installations.

Noise levels shall be measured 1,500 feet from the centre of the compressor station on north, south, east and west lines or at appropriate points 1,500 feet from the centre as prescribed by the Agency.

2) Achievable noise levels will vary from one station site to another depending on topography and vegetative cover, but shall in no case exceed those prescribed in recommendation 1.

3. The Company shall comply with higher standards of operating compressor station noise attenuation in those sensitive areas such as the Delta or North Slope as may be required and specified by the Agency.

4. The Company shall monitor the noise level of each compressor station as prescribed by the Agency and report the results to the Agency within six months of startup of each station.

5. The Company shall make a detailed survey of each compressor station location and shall submit its survey results, noise attenuation rationale, and compressor station equipment specifications to the Agency for review and approval in the final design.

RECOMMENDATION: THE GOVERNMENT

6. The Government should identify those areas in which compressor station noise attenuation measures above and beyond conventional, may be necessary to protect populations of wildlife or birds.

SOURCES OF INFORMATION

1. Transcirpts, Exhibits, Basic Documents

CAGPL Koskimaki, C.M. (31:3935-3937)

Foothills Beer, P.A. (63:9006)

CAGPL Application 8.b.1.4.3

2. Reports

National Energy Board.
1976 CAGPL response to question 13, Deficiency Letter No.4.

Dailey, T. and D. Redman
1975 Guidelines for roadless area campsite spacing to minimize impact of human-related noises; USDA Forest Service General Technical Report PNW-35.; Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

3. Personal Communication

Noise and Vibration Section, National Research Council, Ottawa.

BLOWDOWN NOISE

GENERAL RECOMMENDATIONS

The Company shall attenuate the noise of compressor station maintenance blowdowns and similar pipeline noises so as to minimize disturbance to people and wildlife.

DISCUSSION

Pipeline blowdowns are conducted under emergency conditions and as normal maintenance operations. Emergency situations make attenuation measures difficult or impossible and are not dealt with in these recommendations. Normal pre-operational and maintenance operations require that certain piping associated with compressor stations, scraper traps and dual river crossing sites must on occasion be blown down to lower than existing pressures, in many cases to atmospheric pressure. These procedures normally create very loud noises lasting several minutes. The first 10 seconds or so can range as high as 140 dBA or the threshold of pain (Lancee p.31). Mirosh (63:9105) said a maintenance blowdown can be kept to the level of a whisper, while Beer (63:9106) said it <u>can</u> be controlled so that it is no louder than a normal operating station.

Also, before operation of a pipeline, the air in the pipe must be expelled (purged) by incoming gas pushing a rubber sphere along the pipe. This operation creates a lower volume, but similar noise.

Wildlife and people could be disturbed by the sudden very loud sound of purging and blowdown. Habituation is not possible since there is no short interval regularity or periodicity to these activities.

Wildlife would exhibit fright-flight reactions at each occurrence and might ultimately desert the area permanently. For people it could be an intolerable startling intrusion producing a widespread change in body activity and perhaps impairment of hearing (Lancee, p.22).

RECOMMENDATIONS

1. The Company shall attenuate maintenance blowdown noise at each station by appropriate choice of vent line diameter, blow off tanks and duration of operation or other appropriate means so that the blowdown noise at the location used for measurement of background station noise is not greater than the allowable operating noise level of the particular station at that location.

2. The Company shall not purge the pipeline without warning residents who may be within rangeand shall not purge the pipeline when concentrations of wildlife or waterfowl are in the vicinity that could be unduly disturbed (see sections on birds and mammals), or shall sustain the dura tion of the purging so that the noise level does not exceed 50 dBA 1,000 feet from the site of operations (see also Recommendations under "Blasting").

3. In those locations where blowdown noise attenuation devices are lacking but blowdown procedures must be used to expel liquids or foreign material from the pipe concentration of wildlife or waterfowl are in the vicinity that could be adversely affected (see also sections under "Wildlife Protection").

SOURCES OF INFORMATION

1. <u>Transcripts, Exhibits, Basic Documents</u>

CAGPL Hurd, L.G. (42-5432-37)

Foothills Panel on Compressor Station Design (63:9104-08)

2. <u>Reports</u>

Lancee, B.W.
1970 Noise abatement at compressor stations; Paper presented at National Technical Conference of the Canadian Gas Association.

CONSTRUCTION SERVICES AND ACTIVITIES

BORROW OPERATIONS

GENERAL RECOMMENDATIONS

The Company shall select, open, develop, operate, close and restore all pits and quarries in such a manner as to minimize disturbances to land and the environment and minimize the amount of land used and materials extracted.

The Company shall provide detailed technical and environmental information about each preferred borrow site and about possible alternate sites, with the proper environmental impact, advantages and disadvantages of each.

The Company shall develop detailed plans, covering all aspects of selection, access, development, closure, restoration and abandonment of each pit or quarry proposed to be used. The individual plans shall be submitted to the Agency for approbation. No work shall commence in the absence of such approbation.

If any pits or quarries are proposed for development jointly by the Company and any other party, the conditions recommended in this submission shall apply.

For all gravel removal schemes in river channels or flood plains, the Company shall ensure that fish resources are protected both during and after the gravel operation. This will require that each potential site be assessed as to its fish resource use before operations start and that close control of the operations be maintained during removal and rehabilitation of the site after use.

As part of final design and before the granting of site-specific approvals, the Company shall develop an Overall Plan for the extraction of borrow, listing all the sources proposed to be used, the quantities and grades that will be taken from each source, the time of year that the sites will be worked, the purpose, timing and point of use of the materials and the competing requirements for borrow materials in the project area.

DISCUSSION

The development and operation of a borrow pit or quarry causes disturbance to land and to the landscape. It also has a potential for severe impact on waterbodies, aquatic organisms,

mammals and birds. The disturbance of landscape is manifest by the loss of visual amenity resulting from unsightly pits and unnaturally exposed rock faces, often of considerable extent. The operations themselves can be noisy, and can involve the production of considerable quantities of dirty water, particularly if processing operations such as crushing, screening or washing are involved. Quarry operations also necessitate drilling and blasting; these activities may be necessary if pits are excavated into frozen soils. In permafrost areas, borrow extractions can result in continual thawing of ground ice, possibly leading to soil erosion, destruction of vegetation, soil slumping, land subsidence and the deposition of sediment on land or its discharge into waterbodies.

The large number of pits proposed by the Applicants will cause considerable impact. Canadian Arctic Gas proposes to develop about 126 pits while Foothills proposes about 80 pits for the main line, with a further 18 for the Great Slave Lake community service lines. The various land and environmental impacts cannot be eliminated, if the project is to go ahead. Hence, the objective of terms and conditions must be to reduce the range and intensity of impacts to a level where protection is considered to be adequate. This will involve control, on a site-by-site basis, of location, timing and rehabilitation.

Impacts of borrow operations are site specific; that is, they are a function of the local terrain and biota. Thus, terms or conditions for borrow operations should likewise be site-specific and designed to meet particular concerns about individual pits and their operation. Unfortunately, this kind of site-specific recommendation can not be made at this time because the Applicants have not finalized individual pit locations or the plans for their development. Hence, such specific recommendations must be left to those who will be charged with review of final design. The recommendations below provide advice to those charged with developing and reviewing such plans. Detailed, site-specific development plans coupled with careful site selection and conscientious restoration can go a long way toward alleviating most of the problems.

There are no fundamental differences between the proposals of the two Applicants for selection, operation and rehabilitation of borrow pits. Potential impact of borrow operations for construction of the Foothills mainline (excluding the

northernmost 50 miles) does not appear to differ appreciably from that related to the Arctic Gas mainline, despite the somewhat smaller overall borrow requirement of the Foothills project. Borrow sites required for the Prudhoe Bay line gave rise to concerns for fish, mammals and birds that are greater than those encountered in the Mackenzie Valley. Concerns for the substantial borrow extraction required for the Arctic Gas cross-delta line are rather less than those arising from the proposed fall construction of the northern part of the Foothills mainline. Information on the borrow operations for the Foothills Great Slave Lake community service lateral is not yet available.

The operational proposals contained in the Canadian Arctic Gas Responses Volume (Appendix A) and, for Foothills, in a report by Loram International Ltd. (1976) are generally acceptable. Some additional restrictions are proposed, however, to improve the level of environmental protection.

Special concerns arise over the proposals by both Applicants to extract gravel from the channel zones of some streams and rivers. From the construction point of view, the most desirable granular borrow materials are fluvial gravels, (gravels transported and deposited by flowing water). The majority of fluvial gravel deposits that the Applicants propose to work are not closely associated with present day rivers; they are either glacio-fluvial (deposited by proglacial or interglacial streams at the end of the last ice age) or terrace gravels, deposited at a time when the present stream was flowing at a higher level, a level that is now abandoned as the stream has deepened its valley. There are, however, certain economic advantages to extracting gravels from the channel zone of present-day rivers: such gravel tends to be unfrozen and can therefore be mined easily and the pits do not need much treatment after the mining is completed because they can obviously not be revegetated and the river will re-shape the pit floor in due course. Consequently only levelling is proposed. This, and the lack of other gravel sources along certain parts of the proposed pipeline route, are the main reasons why a certain amount of gravel extraction on flood plains and in channel zones is being proposed by both Applicants. Since gravel is important for fish spawning, nursery and food production, there could be conflicts between the requirements of the project and of fish in areas where gravel is in short supply. The potential impact of gravel removal on the fish resource is by reduction and siltation of habitat or by the trapping of fish in uncontoured pits left by the operation. From

a fish and fisheries viewpoint, watercourses are not a preferred source of gravel. However it is recognized that for development or aesthetic reasons, this may be the best overall option in some areas.

Tbe difference between borrow pits in the channel zone and on flood plains is that the river is allowed to flow through the channel zone excavation after work is completed whereas it is to be prevented from entering or flowing through flood plain excavations on a permanent basis. (Note that the terms "channel zone" and "flood plain" are used here as defined in "Crossings: Definitions").

If the pit area in a channel zone is not clearly separated from flowing water with dikes, e.g. if extraction is carried out under flowing water or if drainage water from the pit re-enters the stream without passing through adequate settling ponds, considerable silt loads can be imposed on the river during borrow operations. This is an effect that can, at the worst, last only a little longer than the borrow activity but, if this period happens to be critical for fish or if the silt settles in areas used as spawning beds, there would be considerable and permanent damage. Otherwise it may be temporary and inconsequential.

Fuel or oil spills from equipment working in flowing water is also a possibility that has to be kept in mind.

River gravels are very permeable so that it is difficult to keep large, deep excavations in river beds dry. Vast amounts of seepage water (probably silty and oily from flowing through the excavation) would have to be pumped. This is not being proposed, the plan being rather to excavate shallow deposits over large areas, with the bottom of the excavation not much below nearby stream water levels. Deep excavations also could develop into fish traps. Arctic grayling are readily trapped by pools that dry up or lose their connection with the main channel on a falling stage of the river.

The most suitable conditions for borrow operations in channels occur when the flows are low, when no important fish spawning or migrating activities are underway in the river reach affected by the excavation, and when the gravels are unfrozen. Such periods are rather short (no more than three months in late summer and fall) so that a great burst of activity will be needed, with all

the problems that this entails. There is little flexibility; extraction cannot be carried out at other times.

Since most other pipeline and facility construction activities along the Yukon North Slope will be concentrated in winter, when Canadian Arctic Gas expects to utilize a system of snow roads, the question arises as to how gravel mining equipment is to be taken to North Slope rivers. Canadian Arctic Gas indicated that snow roads will be built specifically for this purpose one year ahead of the main construction season.

After the gravel mining operation has been completed the river may probably be allowed to flow through the excavated areas and at this time, if not before, a considerable slug of additional silt may be picked up. If this occurs during a significant flood, when the natural silt load is large, it may be inconsequential. Other pollutants left behind in the pit areas may also be picked up at that time. Keeping the river permanently out of pits within the channel zone would require extensive river training works and continuous maintenance. Generally this is not feasible.

The effects of removing significant quantities of river bed material from a river channel depend on the rate at which these materials are normally being transported by the river. In very active channels carrying large quantities of gravel the effects of mining may be relatively short-lived (a few years) and may remain restricted to the pit area. Compared to all other possible borrow sites, river channel zones of this type have the advantage that the landscape is not permanently scarred.

The effects of gravel extraction are likely to be much more severe, and to last much longer in inactive channels, carrying little gravel. A fairly general lowering of the channel bed over a considerable distance above and below the actual pit site could result -- an effect that may or may not be significant depending on factors such as the extent of the flood plain and the bank stability of the channel.

Flood-plain pits unlike channel zone pits are meant to remain permanently separated from the river but will generally contain water for at least part of the year. Some will be artificial lakes, possibly offering some opportunities for environmental enhancement. If some of the shoreline falls into ice-rich material there will be shoreline stability problems due to lake

water melting permafrost. Revegetation of the pit floor will, in general, not be possible and most flood plain pits will be eyesores for a long period.

Depending on the location of flood plain pits, there is the danger that the river could, in the course of a large flood, change its course and flow through the pit, if this produced a more direct route down the valley. Buffer zones and permanent dikes are proposed to prevent this. The flood plains along northern rivers tend to be biologically more productive than the surrounding tundra or boreal forest and since the vegetation cannot be restored after borrow extraction, some productive terrain will certainly be lost.

Borrow extraction in general gives rise to many serious concerns, but the specific concerns associated with gravel extraction on flood plains and in channel zones are somewhat less prominent mainly because the number of such pits proposed is relatively small. The main exception to the above occurs along the Yukon North Slope, where the major part of the gravel requirements is to be met from channel zones. Along the alternative Interior route there are three channel zone pits and at least one flood plain pit proposed, out of a total of 19 pits.

Along the routes from the Mackenzie Delta to Alberta there are significant differences between Canadian Arctic Gas and Foothills. Arctic Gas does not propose to mine any channel zones along that route but there are a few flood plain pits. There is a firm commitment not to use gravel bars in the Mackenzie River and gravel spits along the Beaufort Sea coast (<u>see</u> "Birds").

Foothills claims that it would not disturb the stream beds of smaller rivers and streams to remove gravel and when pressed to define such rivers, goes as far as stating that the Willowlake River would not be one of them (the implication being that it might remove gravel from such a river). Foothills is also considering using gravel from at the mouths of certain tributaries to the Mackenzie (whether above or below water is not stated) and permanently submerged bed material of the Mackenzie River itself. The former needs to be rejected because most river junctions along the Mackenzie River are significant areas for biological, social and archaeological reasons. The latter may have some merit since there has been considerable dredging in the Mackenzie River in the past which has apparently caused no damage.

Finally, there is one activity over which there is some concern, and which is closely tied in to borrow extraction. This is the production of concrete for the pipeline project. Concrete will be needed for the foundations for heavy stationary machinery at the compressor sites, for building foundations in some areas and related jobs. It will also be required for buoyancy control along tbe pipeline in the form of concrete weights, or as a continuous concrete jacket for some river crossings.

Canadian Arctic Gas expects to use 115,000 concrete weights, of five tons each, in the Northwest and Yukon Territories. Foothills was not able to give a similar estimate of the number of weights it expects to use. These weights will be cast in the field using local aggregate and imported cement. The weight-casting may be done in summer and could be done at the aggregate source, the point of use, at a compressor station or other gravel pad.

The potential impacts and concerns of this activity include the unnecessary consumption of high grade aggregate, water consumption, the muddying of waterbodies by gravel processing or concrete washing, increased land use for weight casting and storage areas and water pollution by spills of cement or lime.

The Department of Indian Affairs and Northern Development is presently developing Regulations under the Territorial Lands Act to govern the opening and operation of pits and quarries in the Northwest and Yukon Territories. These regulations are expected to provide for a system of licences or permits, rules for the conservation of materials, terms and conditions governing the actual operation, reclamations and abandonment of any site, security deposits, royalties, fees and other matters. The regulations will also include a schedule of permitted uses of materials, as a major part of the conservation program.

As these regulations are still under development, the following recommendations have been written to be comprehensive. In cases of conflict between these recommendations and the regulations as finally promulgated, the more conservative requirements should apply.

The following recommendations have been divided into Overall Recommendations, which apply to all proposed pits and quarries; Borrow Pits in Flood Plains; Borrow Pits in River Channel Zones

(for definitions see "Crossings: Definitions"); and Weight Casting.

RECOMMENDATIONS

Overall Recommendations

1. The Company shall make individual applications for permission to open and develop each borrow pit or quarry necessary for the construction of the pipeline and associated facilities.

2. Each application shall be accompanied by a site plan, a mining or extraction plan and sufficient geotechnical and other information so as to clearly demonstrate the viability of the proposed development. In particular, the Company shall carry out sufficient geotechnical investigations of all potential pit or quarry sites to ensure that no sites are opened that are subsequently found to contain unsuitable material or insufficient suitable material to justify the existence of the pit or quarry.

3. Each application shall be accompanied by a description of one or more possible alternative sites, with the probable environmental impacts of developing both the preferred and the alternative sites and a statement of the relative merits of the preferred and alternative sites.

4. As part of the approval process, the Agency shall either confirm the selection of the preferred site, or direct that one of the alternate sites be developed, or that a combination of sites be used. No work, including preparatory activities, shall commence at any site in the absence of a specific statement of approval from the Agency.

5. Borrow sites shall be selected, operated and restored in locations and in a manner that complies with the recommendations proposed for the protection of birds and mammals listed in "Wildlife Protection".

6. The site plans and mining plans shall provide the following information:

   a) details of the borrow "source" area, thickness, quantity, grade, test pit and bore hole data;

b) the placement of the pit and its boundaries in the source area, with estimates of the quantities and grades proposed to be used and remaining;

c) the occurrence of permafrost, ground ice and ground water and the location of the water table;

d) details of the machinery proposed to be used, the timing of the various operations and the details of any processing operations that may be used;

e) details of the access to the pit initially, and from the pit to the point of use of the material;

f) plans for drainage, erosion and sediment control during operations;

g) the final form of the pit or quarry, with details of the restoration proposals, including spoil disposal, drainage and revegetation;

h) an environmental impact statement; and

i) any other information required by the Agency or by the Administrator of the Territorial Pits and Quarries Regulations.

7. In selecting potential borrow sites, the Company shall observe the following restrictions:

a) geotechnical investigations to locate potential borrow pits are to be done with drills, jack-hammers and backhoes; bulldozers, bucket-loaders and extensive excavation shall not be used;

b) all test pits in areas that are not to be used for borrow extraction shall be backfilled and the location rehabilitated;

c) deposits of high ice-content material, of material covered with high ice-content overburden or of borrow material overlying high ice-content silts and clays shall be used only if no other material is available; and

d) wherever possible existing borrow sites shall be used in prefence to the opening of new sites.

8. In developing borrow sites, the Company shall comply with the following:

a) access roads shall be routed along existing roads, trails or cutlines wherever possible;

b) new access roads shall be cut to a minimum width commensurate with safe operations;

c) temporary access roads shall be constructed of packed snow or ice; for standards see "Snow Roads";

d) any pit designated for summer operations or for continued use during the operational phase of the pipeline shall be provided all-weather, gravel access road, with culverts; and

e) "low-water crossings" shall not be permitted in any borrow pit or quarry access roads.

9. In the operation of borrow sites, the Company shall comply with the operating principles as detailed in the "General Criteria For Gravel Borrow Pits in Upland Areas" and in the "General Criteria for Quarry Sites", Appendix A of the CAGPL Responses to PAAG, pp. 45-49 and 59-62 (CAGPL, 1974) and with the following:

a) Buffer zones of not less than 300 feet shall be left between all waterbodies and the final limits of all pits and quarries.

b) Buffer zones of not less than 100 feet shall be left between all public roads and the final limits of all pits and quarries.

c) The processing of any material is to be done either in the borrow area or at the site of use of the material, and nowhere else.

d) Noisy operations, such as blasting or crushing, shall be undertaken in a manner and at times acceptable to the Agency (<u>see</u> also "Blasting").

10. In closed and abandoned borrow sites, the Company shall comply with the "General Criteria" noted in Recommendation 9, and with the following:

    a) Closed pits shall not be left in a derelict state, but shall be stabilized and rehabilitated promptly.

    b) The rehabilitation of any pit or quarry shall not unduly hinder other parties from re-opening the sites for further use, some time in the future.

    c) Any part of a closed borrow pit or quarry where waste material other than spoil or slash has been buried shall be permanently marked (<u>see</u> also "Solid and Liquid Wastes: Construction/Industrial Activities").

11. Major changes in borrow pit or quarry locations, operating plans, quantities of material to be removed from any site, closure plans, or any other matter relating to the excavation, transport or placement of borrow material shall be submitted to the Agency for approbation.

12. Any fuel oil or other toxic materials stored at or adjacent to borrow sites shall be placed in areas not subject to wetting by ponded surface waters, in areas where vehicles and work equipment cannot damage tanks, bladders or stockpiles of material, and in areas where spills of liquids will be naturally contained. In the absence of suitable material areas within the borrow sites, impervious berms shall be constructed (<u>see</u> also "Spill Prevention and Control").

13. Because of the destructive nature of any borrow pit and quarry operations, special care shall be taken in carrying out archaeological surveys of such areas during their development.

<u>Borrow Pits in Floodplains</u>

14. In the case of flood plain borrow sites, a buffer zone of 300 feet of undisturbed flood plain terrain is to be left between the channel zone and any proposed flood plain borrow pit.

15. Dikes and river training works are to be constructed to assure that the pit does not become connected with the river

and to prevent the river from changing its course through the pit. The river training works are to be designed for the 1-in-100 years flood condition.

16. Future water levels in the abandoned pit are to be taken into account in planning the rehabilitation of the pit.

Comment: Since flood plains are flooded occasionally (by definition) the floor of any flood plain excavation is likely to be flooded frequently or it may become permanently submerged. Revegetation needs to take proper account of this.

Borrow Pits in River Channel Zones

17. The Company shall not open any borrow pits in river channel zones in the Northwest Territories.

Comment: Only a few channel zone pits are being considered by the two Applicants and they conflict with the existing Fisheries Guidelines used in connection with construction of the Mackenzie Highway. In particular, channel zone pits in Willow and Trout River and Francis Creek would be unacceptable.

18. Gravel is to be extracted from stream channel zones only under the following circumstances:

a) the stream has to have a braided pattern as defined in

b) the channel zone has to be at least three times as wide as the proposed mining operations, and any one pit cannot be longer than the average channel zone width in the reach covered by the pit;

c) successive pits in the same stream are to be separated by a distance equal to at least the channel zone width;

d) no more than three pits are permitted in any one stream;

e) gravel removal shall not occur within one mile of well defined fish spawning, overwintering or rearing areas;

f) the total quantity of gravel removed from any channel zone should not amount to more than twenty times the estimated normal annual gravel load of the stream.

Comment: One of the main factors in favour of channel zone borrow pits is the gradual healing of the scars due to he river's ability to re-shape the channel zone. The specified limit on the size cf pits and the required gravel supply from upstream assure that this does in fact occur over a reasonable period. There is no evidence on the length of time that should be specified.

19. In addition to the application requirements for borrow pits listed in recommendations 1-3 and 6, the application for a channel zone pit shall include the following items.

a) Maps and cross sections showing stream channels, the channel zone and flood plains as previously defined, also the main features of the extraction scheme, e.g. windrows, dikes, stockpiles,
fuel storage areas, camps, temporary stream crossings etc.

b) Plans for getting machines to the mining sites without damaging terrain.

c) Conclusive biological evidence showing that the proposed scheme is not harmful to the fish resources of the river.

d) A contingency plan for pollution accidents.

e) An analysis of the hydrological regime of the stream giving the following general information:

(i) probable distribution of flows during a normal year;

(ii) expected extreme high and low flows at roughly the 0.04 level, for each month during which gravel extraction in the channel zone is contemplated; and

(iii) an outline of the data and procedures used in obtaining the above, with comments on the reliability of results.

f) An analysis of the sediment transport regime of the stream, including: graphs showing the dependence of sediment transport rates on water discharge, with comments on the reliability of the results; a comparison between the quantities of gravel to be removed and the average yearly gravel transport in the river, and notes on the natural rates of channel shifting.

20. The layout of the extraction operations is to be planned in such a manner that interference with the stream environment is minimized. All overburden, debris and brush shall be removed to a location above the maximum high water-wetted perimeter. Minor channels may be shifted in order to dike the perimeter of the mining operation; major re-channelization shall be avoided. Fish migration routes shall be left clear at all times, and natural drainage through the site shall be maintained. Whenever possible, gravel shall be removed from outside the normal high water-wetted perimeter of watercourses.

21. The borrow operation is to be diked to assure that no surface flows can break into the mining area. The 1-in-25 years probability level applied to the period when the dikes will be in service is to be used in designing the dikes.

22. Extraction shall not be carried out to a depth lower than the average channel floors in the vicinity of the operation.

23. All borrow operations are to be carried out in dry pits under normal circumstances and under no circumstances is work to proceed in more than 2 feet of water.

<u>Comment</u>: Working in water is not desirable because it reduces the chances of successfully cleaning up a pollution accident. River gravels are very permeable so that the silty (and possibly oily) water in the pit could easily contaminate groundwater or the nearby river.

24. After completion of the operation and before the first spring runoff, or if the water course enters into the site at any time and the site is unusable, the perimeter dikes and access ramps are to be removed and the area of operation is to be left as a gently sloping plane surface with no depressions readibly accessible to re-occupation by stream channels. Any excavation shall be connected to the stream at its downstream end by a stable, sizeable outlet having the same lower elevation as the bottom of the excavation (to prevent the trapping of fish in low water periods). Stream channel banks are to be re-formed to their original shape and revegetated.

25. Borrow operations are to meet the same suspended sediment standards as any other pipeline-related activity (see "Suspended Sediment Standards").

26. Dredging for borrow in the Mackenzie River may be permissible, under the following conditions:

    a) detailed site - and time - specific applications are submitted following the schedule proposed in Recommendation 19;

    b) the Company must demonstrate that the proposed activity will not interfere with shipping, fishing or other traditional human activities;

    c) the Company must show that the proposed activity does not disturb any sensitive area and does not take place at a sensitive time for fish;

    d) disturbance of river bars and islands used by migrating waterfowl is prohibited (see "Birds"); and

    e) dredging at, in or near the mouths of significant tributary rivers is prohibited.

<u>Weight Casting</u>

27. Concrete weights shall be made using the lowest grade of aggregate available that will produce concrete with the necessary properties.

28. Water required for concrete production shall be withdrawn in accordance with the standards recommended in "Water Supply and Intakes".

29. All wastewater, wash water and surface run-off from gravel processing, or weight casting operations and areas shall meet the standards as set out in "Suspended Sediment Standards".

Comment: Where runoff water has an unacceptable silt load, stilling ponds and sediment traps will be required.

30. Every possible effort shall be made to avoid the spilling of cement, lime or related industrial or manufactured material. Any spills which do occur shall be cleaned up forthwith and the land rehabilitated or restored. Under no circumstances shall spills of cement, lime or related materials be permitted to enter any waterbody.

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BLASTING

GENERAL RECOMMENDATION

The company shall conduct all blasting in a manner that minimizes the disturbance to all aspects of the living environment.

DISCUSSION

Blasting is a necessary part of pipeline construction that is governed by standard engineering practices. Under most construction circumstances, these practices are sufficient to produce a safe, efficient explosion. However, the use of explosives for the pipeline project in the North will require additional precautionary measures to assure compliance with particular environmental and socio-economic constraints.

The main problem with blasting is its disturbance to fish and wildlife. The concerns and recommendations for fish are dealt with in "Underwater Blasting". Many of the recommendations of that section are equally applicable to aquatic mammals like muskrat, beaver and whales. This section expands the subject to human and wildlife concerns in general.

There will be substantial blasting activity. Arctic Gas estimates that over 10,000 tons of explosives will be required for its project. Foothills has indicated that approximately half of its route will require some blasting. Blasting will occur in all seasons for a variety of pipeline activities including: river crossings, borrow material excavation and preparation, facilities construction, and right-of-way preparation. Whatever route is finally chosen it will pass through areas where blasting will have the potential for unacceptable disturbance. The variability of terrain conditions makes it certain that blasting will occur at unanticipated places at unforeseen times. The danger of adverse impact will increase if pre-blasting were used as a method of increasing ditcher productivity.

The major wildlife concerns with respect to blasting are primarily associated with disturbance to caribou, waterfowl, raptors and whales during sensitive periods or periods when they are concentrated in certain areas (see "Wildlife Protection"). The effect with respect to aquatic furbearers, and perhaps whales, may be more direct and lethal. Blasting is capable of destroying muskrat pushups, beaver lodges and dams. It can also

injure or kill these mammals if charges are set off close to their habitat. As the native people rely on muskrat and beaver for fur trapping and to some extent for food, the concern is far greater than the risk to the animal population alone.

Adverse effects of blasting on wildlife can be minimized by scheduling when species are not in the area or by controlling the frequency and level of the blast. Whatever the method, the Company must regulate its activities to assure unacceptable impacts are avoided. Blasting may upset conditions for native peoples' traditional pursuits. The Inquiry has heard numerous complaints in the community hearings about the adverse effects of seismic operations. There is great aprehension that blasting associated with the pipeline will further "ruin" the land. The disruption of wildlife resources and the traditional pursuit of these resources by northern people must be kept to the very minimum. This will mean that the Company will have to be particularly cognizant of traditional pursuit areas and schedule its blasting activities accordingly.

RECOMMENDATIONS: THE COMPANY

1. The Company shall confine all blasting operations to areas sold, leased or otherwise appropriated to the Company for its use.

2. The Company shall limit and otherwise appropriately control its blasting activities at times and in areas important for wildlife. In particular the Company shall ensure that the following species and their habitats are protected:

    (a) Raptors: blasting activity within the Raptor Protection Zones during sensitive periods shall be prohibited except if specifically otherwise approved by the Agency (<u>see</u> "Rare and Endangered Species").

    (b) Waterfowl: blasting activity in areas habituated by nesting, moulting, staging etc. waterfowl shall be severely constrained to limit the disturbance to the birds so that their normal activities are not interrupted in any way (<u>see</u> "Birds").

(c) White Whales: blasting shall not occur within one mile of marine or estuarine waters when such waters are being utilized by aggregations of migrating, calving or post-calving white (beluga) whales (see "Terrestrial and Aquatic Mammals").

(d) Caribou: blasting shall be prohibited in any location that might disturb or alarm migrating, calving, post calving or any aggregation of caribou (see "Terrestrial and Aquatic Mammals").

(e) Aquatic Furbearers: blasting in populated aquatic furbearer habitat should be avoided by utilizing all feasible alternatives. Where blasting must occur, the Company shall conduct its operation in a manner that assures the continued well-being of the furbearer population (see "Terrestrial and Aquatic Mammals").

3. In all locations where blasting is planned, the onus of proof that the operation will not cause short or long term harm for the fish and wildlife in the area, shall rest entirely with the Company.

4. The Company shall notify local people at least one month in advance of blasting operations in areas that are traditionally, currently or seasonally used by those people.

Comment: The use of lands by northern people is extensive. These people should not have their activities interrupted, altered or precluded by blasting activities. The onus must be on the Company to develop a blasting schedule and a local communication program that will ameliorate this problem.

RECOMMENDATIONS: THE GOVERNMENT

5. Prior to approving construction activity in any area, the Agency should define the areas and probable times of sensitivity of wildlife and fish to blasting activity. During construction the actual locations and periods should be firmly established and updated blasting activity issued to the Company.

6. The Agency should prohibit any blasting activity in areas utilized by native people for hunting, trapping or fishing until those people have been advised of the activity and given the opportunity to harvest any wildlife that would be adversely affected.

SOURCES OF INFORMATION

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WASTEWATER AND SEWAGE: CAMPS AND FACILITIES

GENERAL RECOMMENDATION

The Company shall eliminate the public health hazard and minimize the environmental degradation caused by wastewater and sewage emanating from construction camps and permanent pipeline facilities by the application of a site-specific, environmentally responsive wastewater management program utilizing practicable technology.

The Agency should ensure that the site-specific wastewater management scheme proposed by the Company is tailored to the capabilities of the receiving environment. The standards set by government should be cognizant of treatment costs and the overall environmental ramifications of such standards.

DISCUSSION

The procedures used to eliminate the public health hazards associated with waste are well understood, nationally recognized and well documented in existing regulations and legislation. They require little amplification here except to note that recent studies confirm that indicator and pathogenic organisms have a longer survival period in the northern environment than in the south. The potential for health related problems is therefore greater.

On the other hand, procedures to minimize the adverse effects of waste disposal on the receiving environment are not as well understood, are not nationally recognized and are not well documented in existing regulations and legislation. Various guidelines and "accepted procedures" do exist but these vary in themselves and are often not reflected in actual waste disposal practice.

Many communities in the North have only the most rudimentary waste handling systems; outhouses, "honey buckets" and trucked pump-out systems are the rule rather than the exception in native communities. The treatment of wastewater is virtually non-existent except in the larger white-dominated communities such as Pine Point, Hay River, Yellowknife and Inuvik. In this light, and considering the dumping of raw wastes from large urban areas in the South, one must seriously question the priority that should be given to the spending of large amounts of money on waste treatment for a relatively short term construction project

in the North. Although this is not an example to be followed, this perspective should simply reaffirm the objectives of providing a wastewater management scheme that:

(a) provides public health protection at any cost; and

(b) results in an effluent discharge tailored to the natural characteristics of the receiving environment utilizing the best practicable methods of treatment

The pipeline project in the North will result in an influx of thousands of people who will be spread over a vast area but who will be working in concentrated groups for relatively short periods. The potential for a substantial localized environmental shock is high -- particularly considering that most of the work will be done in winter when the potential adverse effects of waste on receiving waters are greatest. Therefore it is essential that the Company adopt wastewater management and treatment procedures at each location which will minimize the environmental impact of its presence. Also, the location of pipeline related facilities should be selected so that effluents generated at the sites will have the least effect on the surrounding environment.

Minimizing the environmental impact of waste disposal must be done by site-specific analysis of two factors: (1) the nature and volume of the waste produced, and (2) the nature and assimulative capability of the receiving environment. Construction camp effluent has been shown to be very concentrated. It would be irresponsible to lay down blanket-type effluent standards that ignore the influent characteristics and the site-specific characteristics of the receiving environment. Therefore, current federal guidelines and the standards proposed by the pipeline companies will not be applicable in all cases. Each site must be evaluated <u>on its own merits</u> and effluent requirements established that consider the overall significance of what treatment facility would be required to achieve those standards. It may be that in certain cases, during some periods of the year, the receiving environment could accept without any marked change an effluent that had undergone only the most rudimentary treatment.

Both pipeline companies have approached the problem of wastewater and effluent disposal from the same perspective; indeed, they both used the same consultant. Essentially they say that the

effluent from large camps will receive secondary treatment and effluent from smaller mobile camps will receive primary treatment. Little, if any, attention has been given to the nature of the receiving environment largely, perhaps, because the location of activities has not yet been finalized. The impression given is that in final design site-specific investigation will lead to site-specific proposals. This is the correct approach but it must be clearly established by the imposition of specific recommendations.

Finally, from the experience both in Alaska and Canada, it appears that the critical operating considerations will be: (1) a well trained and conscientious operator, and (2) a well designed treatment facility that will not be hydraulically or biologically overloaded.

RECOMMENDATIONS: THE COMPANY

<u>Overall Plan</u>

1. Before final design and before any site-specific approvals are granted, the Company shall prepare an Overall Plan for the disposal of wastewater and sewage from all construction activities and all permanent pipeline facilities over the life of the project up to and including abandonment. The Overall Plan shall be in graphic (map) form as far as possible, shall be presented by drainage basin or part thereof and shall be cognizant, by means of overlays or graphic presentations on the same scale or notations on the same document, of the Overall Plans for "Water Supplies and Intakes", "Solid Wastes: Camps and Facilities", "Solid and Liquid Wastes: Construction/Industrial Activities", "Pipe Testing", "Snow Roads", "Spill Prevention and Control" etc.

<u>Comment</u>: The Overall Plans will form the overview basis for assessing the related impacts of all activities associated with water use and disposal of wastes during construction, operation and abandonment of the project.

2. The Overall Plan shall specify:

   (a) the points of generation and disposal of waste;

(b) the proposed methods of collection, storage, treatment and disposal of all waste;

(c) the anticipated volumes, chemical and biological characteristics, and periods of discharge of all waste;

(d) the general physical and biological characteristics and domestic and/or commercial utilization of the receiving environment;

(e) the source and disposal plan for any hazardous or toxic waste; and

(f) alternate sites and/or treatment methods that could be used if the proposed site or method is unacceptable to the Agency or if the proposed site has to be excluded for any reason during the life of the proposed activity.

Site-Specific Application

3. A separate site-specific application must be filed with the Agency for each wastewater or sewage disposal discharge regardless of the quality, rate or duration of the discharge except a group application may be permitted where two or more disposal sites are in the same watershed, will be used during overlapping periods and will result in similar treatment methods and effluent standards.

4. Each application to discharge wastewater or sewage shall be keyed to the Overall Plan.

5. Each application shall specify in detail:

   (a) the normal and maximum population of the facility from which the waste will be generated;

   (b) the complete design parameters for the proposed facility for disposition of waste including a documented estimate of the quantity of waste and its chemical, physical and biological characteristics;

(c) the design and operating considerations for handling upset conditions such as surge flows, hydraulic overloading, equipment failures, biological process collapse, etc.; and

(d) the particular characteristics of the receiving environment, including its utilization by wildlife, fish, hunters, trappers or any other people for recreational, professional or any other reason, that were used by the Company in assessing the degree of treatment required and acceptability of the particular discharge site.

(e) the proposed methods and times for monitoring of receiving waters.

6. In the application the Company shall demonstrate, by presenting operational data of that system operating in comparable environmental situations, that the preposed wastewater treatment facility will perform to the standards specified.

7. Applications that are approved shall be valid only for the quantities, qualities, locations and periods of discharge specified in the approved application. If the forementioned are altered in any way that increase or relocate the impact of the discharge, the Company shall submit an amended application for approval before any such change occurs.

8. In all circumstances the burden of proof for demonstrating the effect of a discharge of any wastewater or sewage to the environment shall rest with the Company.

Effluent Standards

9. The degree of wastewater and sewage treatment shall be suited to the assimilative capability of the designated receiving environment. The Company shall demonstrate that the effluent in the quantities and treated qualities proposed will not endanger public health and that it can be sustained by the receiving environment without adverse alteration of any current use by people, fish, birds or mammals. (see Recommendations 46 and 47 below).

10. Unless otherwise approved by the Agency, the general effluent standard shall be as specified in section 4 of Environment Canada's "Guidelines for Effluent Quality and Wastewater Treatment at Federal Establishments" (1976). Under no circumstances will percent reduction of BOD, suspended solids etc. be accepted as a standard for secondary treatment.

Comment: The concentrated nature of most waste from camps may make it difficult and costly to meet the DOE guidelines as noted. They should be considered as general standards until site-specific analyses by the Company or regional analysis by the government indicate the acceptability of less stringent standards. (Also note 38 below). In view of the volume of effluent, its quality and other developments in the area and the nature of the particular receiving environment more or less stringent effluent standards than those outlined may be specified. Irrespective of the treatment system, it may be necessary to utilize Flow Management Resevoirs to prevent discharges during critical, low-dissolved oxygen, times of the year.

11. The minimum effluent standard for all locations shall be primary treatment. The primary treatment shall separate the liquid and solid fractions of the influent and shall be free of debris, scum or other materials that produce colour, turbidity, taste or odour in concentrations which create a nuisance or adversely affect people, aquatic life or wildlife that utilize the receiving environment.

12. The discharge of an effluent without adequate disinfection shall be permitted only where it is proved beyond reasonable doubt that there is no threat to public health.

Comment: To achieve "adequate" disinfection may often require a higher level of wastewater treatment than would be allowable by stream assimilative capacity criteria.

13. The use of chlorine as a disinfectant is discouraged but where it is to be used the Company shall demonstrate that the chlorinated effluent is not toxic to aquatic organisms.

14. Effluent sampling and analytical procedures shall be in accordance with the latest edition of "Standard Methods for the Examination of Water and Wastewater" (American Public Health Association, et al.

15. During construction, composite samples of the effluent shall be obtained and analysed daily for COD and for 5 day BOD and suspended solids to ensure that the specified standards are not being violated. Weekly samples shall be assessed by an approved independent laboratory with the results incorporated into the plant records.

16. During normal pipeline operations after construction, effluent samples and tests as noted above shall be taken weekly at all locations where there are staff on a permanent or temporary basis and tests by an independent laboratory shall be done once every thirty days of cumulative occupancy by operating personnel.

17. The Company shall conduct additional effluent tests, such as fecal coliform, chlorine residual (where chlorine is used as a disinfectant in the effluent stream), nutrients, TOC, etc. as may be required by the Agency or to verify the impact on the receiving environment. (<u>See</u> "Monitoring of Aquatic Environment").

18. Where an effluent stream is discharged directly or indirectly into an identifiable watercourse the Company shall sample the watercourse up- and downstream of the discharge point whenever effluent is being discharged. The samples shall be taken at the same time as the effluent samples and shall be analysed for BOD 5, suspended solids, total coliforms, chlorine residual and other parameters as may be required. The results shall be incorporated into the plant records. Sampling points shall be as outlined in Section on sediment or as otherwise directed by the Agency.

19. For both composite and grab samples, 80% of a statistically reliable number of samples (minimum 5 samples) in any consecutive 30-day period should not exceed the limits specified, nor should any single sample exceed 5 times the specified limit. If these specifications are not met, the treatment system shall be declared "deficient" and the Company shall immediately decrease the population of the camp or facility until the treated effluent complies with the specified standards and is reclassified as "sufficient" by the Agency.

20. Adequate records and operational reports of the wastewater treatment operation shall be maintained on site in a form approved by the Agency and shall indicate raw waste characteristics, waste volumes treated, chemicals used, sludge volumes produced and their final deposition, effluent quality, maintenance done and receiving environment characteristics. During pipeline construction a copy of all records, duly certified by the operator and camp superintendent shall be forwarded to the Agency at the end of each month. During operation the records shall be made available to the government upon request.

Receiving Environment

21. Treated effluent shall not be discharged directly into streams or lakes unless the Company demonstrates that disposal on land or into swamps, bogs or fens is not viable.

22. Treated effluent disposal into swamps, bogs, fens etc. shall be preferred in those areas that have sub-pools with flow throughout the year.

23. Unless otherwise demonstrated, the swampland shall not be used for treated effluent disposal for more than 5 years and shall be of sufficient size to permit approximately 120 square yards per contributing man year. All swamps used for effluent disposal shall be clearly posted, to alert trappers and others that sewage effluent is present.

24. Wastewater disposal shall not contaminate groundwater.

25. The wastewater effluent shall only be discharged to a receiving environment which can assimilate the residual pollutants. Particular attention shall be given to the protection of waterbodies from excessive organic loading during ice cover and low water level periods and to discharges to waterbodies that are quiescent or can become thermally stratified thereby causing localized concentrations of effluent.

26. Unless otherwise noted by the Agency, any effluent disposal that causes deviations from these standards shall be supported in the application by site-specific information and information available from Environment Canada's Water Quality Data Report - "NAQUADAT".

27. All solids and sludges in, or resulting from, the treatment of wastewater or sewage shall be handled in accordance with the requirements as detailed in "Solid Wastes:Camps and Facilities".

Qualified Operator

28. A qualified operator for the wastewater and sewage operations shall be on site:

    (a) at all times for construction and related operations that exceed 200 man days at one location;

    (b) one day a week with a minimum of two visits per site for construction and related operations that are less than 200 man days at one location; and

    (c) as required at permanent facilities on the operating pipeline to perform normal maintenance and repairs except that there shall be a minimum of two visits a year (one of which shall be in winter) or once every 200 occupied man days.

29. A qualified operator shall be an individual who has successfully completed a training program approved by the Agency, and who has a demonstrated knowledge of:

    (a) wastewater treatment processes with the ability to deal with "upset" conditions, start up, surges etc.

    (b) wastewater sampling procedures;

    (c) wastewater tests such as BOD, COD, suspended solids, pH, dissolved oxygen, chlorine residual etc.;

    (d) interpretation and application of laboratory results;

(e) equipment operation, basic repair and preventive maintenance;

(f) basic public health practices; and

(g) safety.

Comment: The company is advised of the following programs and guidelines which should be used in developing a program for operations on the pipeline project.

(a) Operation training program developed by the Water Pollution Control Directorate, EPS, Environment Canada.

(b) Guidelines for the classification of treatment facilities and certification of personnel, Committee on Training and Certification, Federation of Associations on the Canadian Environment (FACE).

30. At locations where a qualified operator is not required full time (see recommendation 28b), one individual shall be designated to assure the safe and proper functioning of all wastewater and sewage systems.

31. The designated individual at locations where a qualified operator is not required full time shall have a demonstrated knowledge of:

(a) wastewater sampling procedures;

(b) steps to be taken to deal with "upset" conditions, start up, surges etc.;

(c) equipment operation, basic repair and preventive maintenance;

(d) basic public health practices; and

(e) safety.

Design Considerations

32. All wastewater and sewage shall be collected and treated prior to disposal in accordance with detailed site-specific plans prepared by the Company, signed and sealed by a professional engineer and approved by the Agency.

33. Each wastewater and sewage treatment systems shall be designed to handle the maximum possible peak flows and surges plus 20% to minimize the chances of hydraulic overloading of the system. The use of flow equalization systems shall be considered mandatory for all mechanical treatment plants. Continuously recording flow meters shall be included at the effluent ends of all treatment facilities. Biological treatment plants at facilities that experience a wide variation in population should use parallel treatment plants to allow organic and hydraulic loading to be within the acceptable range for optimim treatment.

34. All treatment facilities shall include a laboratory fully equipped to make the necessary tests of the wastewater and sewage stream.

35. All continuous flow wastewater treatment facilities which are dependent upon the operation of mechanical equipment shall have temporary emergency storage facilities with sufficient capacity for 10 days' flow of untreated effluent. Pump facilities to return the stored waste to treatment works shall be provided.

36. Duplicate equipment shall be stocked on site for all pumps, valves and aeration equipment essential to the operation of the wastewater treatment and disposal system.

37. All domestic water and sewage systems used in camps or in permanent facilities shall incorporate practices and hardware to minimize the use of water and hence reduce the volume of wastewater produced. This will be particularly important in areas which are environmentally sensitive or sacrosanct and in locations without abundant water.

Comment: All the recommendations contained herein are based on the use of conventional sewage systems and hardware and will be applied accordingly. Where the Company uses low water systems,

as it is actively encouraged to do, the Agency will give special consideration to proposals for the disposal of the resulting effluents such as concentrated sludges, "grey water" etc.

Lagoons

38. Lagoons, used as a method of wastewater and sewage treatment, shall be designed for a minimum retention period of one year under the worst case of ice cover, infiltrated water conditions and maximum population plus 20% to account for unforeseen variations and thus assure, as much as possible, that hydraulic overloading will not occur. The Company shall limit discharge from lagoons during critical (ice cover) periods of the year to assure compliance with receiving water quality criteria.

39. Lagoons shall include a separate primary cell. The sludge shall be cleaned out regularly and disposed of as described in "Solid Wastes:Camps and Facilities".

40. All plans for sewage lagoons shall be accompanied by detailed, site-specific geotechnical and thermal analyses. The materials to be used for waste impounding embankments, their source and permeability shall be specified along with their stability. Seepage control measures shall be detailed.

41. The use of natural waterbodies as lagoons shall not be permitted unless the Company can demonstrate the site-specific benefits of such a practice.

42. Unless otherwise approved by the Agency, sewage lagoons shall not be located within 1000 feet of any waterbody supporting fish, used as a water supply source or utilized by local people for hunting, trapping, fishing or recreational purposes.

43. The Company shall submit for approval, at the time of submissions for initial authorization of the work, specific details of the measure that will be taken when abandoning each lagoon or wastewater retention pit. Upon termination of use, lagoon storage facilities shall be maintained for a minimum of one year or until the water quality is sufficiently recovered to allow discharge of the total contents to the receiving environment. The lagoon area shall

be restored to provide a topography compatible with the surrounding terrain, and revegetated. Abandoned lagoons shall be posted.

Industrial waste to sewers

44. Wastewaters and sewage from industrial operations shall only be discharged to sanitary sewers if they do not interfere with the treatment process and provided they comply with the following guidelines:

(a) the industrial waste discharge temperature shall not disrupt the treatment process or receiving environment;

(b) the industrial waste flow shall not exceed twice the average daily design flow;

(c) the pH of the industrial waste shall be 5.5 to 9.5;

(d) organic and other industrial waste concentrations shall not overload the treatment system;

(e) the limits of toxic materials discharged to sanitary sewers shall be:

Cyanide as HCN:	2mg/litre
Chromium as Cr:	3mg/litre
Lead as Pb:	3mg/litre
Zinc as Zn:	3mg/litre
Copper as Cu:	3mg/litre
Nickel as Ni:	3mg/litre
Cadmium as Cd:	3mg/litre
Phenolic compounds:	1mg/litre
Mercury:	.005mg/litre

Pre-treatment to remove these materials to this level will result in sludges the disposal of which must be detailed and approved by the Agency; hazardous material disposal;

(f) flammable or explosive materials shall not be discharged to sanitary sewer systems but shall be contained and treated as hazardous materials;

(g) animal or vegetable fats or oils shall be limited to 150 mg/litre; mineral oil effluent levels shall not exceed 15 mg/litre;

(h) substances emitting hazardous or noxious gases such as hydrogen sulphide, carbon monoxide or ammonia shall not be discharged to the sanitary system;

(i) wastes containing disolved salts in excess of 1500 mg/litre shall be pretreated prior to discharge; and

(j) the discharge of radioactive materials to sanitary sewer systems shall be prohibited; these materials shall be disposed of according to the regulations promulgated under the Atomic Energy Control Act RSC 1952.

45. Industrial effluents shall not be diluted to comply with the above maximum levels.

RECOMMENDATIONS: THE AGENCY

46. The Agency should review the applicability to this project of the "Guidelines for Effluent Quality and Wastewater Treatment at Federal Establishments" (DOE) and issue revised general standards to guide the Company. Such guidelines should be issued at the earliest possible date and before receipt of the Company's Overall Plan.

Comment: While the Agency should use effluent quality as the ultimate criterion in assessing the adequacy of treatment systems, the quality specified should not be chosen arbitrarily nor should it be based on criteria used for highly populated or industrial areas. Rather, the Agency should, for each major drainage basin, make an effort to project what the maximum development will be. Then, with the aid of data from impact studies and available baseline determinations, establish quality criteria that are reasonable for the area during the season of the proposed activity. Factors which should be taken into account include: (1) the best practicable types of control technology currently available and the degree of effluent quality achievable by each; (2) the total cost of application of the technology in relation to the effluent reduction benefits achieved from such application, (3) the engineering aspects of the application of various types of control techniques and

process changes; and (4) the non-water quality environmental impact (including energy requirements, total resource impact on fish and wildlife, terrain degradation, etc.)

The Agency should be primarily concerned with the quality of wastewater reaching the receiving environment, and to a lesser extent with the degree of treatment efficiency achieved.

47. The Agency should adopt at the earliest possible date a comprehensive list of receiving water quality criteria for wastewater and sewage disposal purposes based on the recommendations as outlined in "Water Quality".

48. The Agency should approve in principle the Overall Plan for wastewater and sewage disposal and the Overall Plans for water supply, industrial waste and solid waste disposal before considering any site-specific submissions for approval.

49. Site-specific plans for each location where wastewater or sewage are to be disposed of should be approved by the Agency before allowing the Company to commence any on-site construction of the camp or permanent facility.

50. Approval by the Agency of site-specific plans for methods of disposal of wastewater and sewage should be conditional on a final on-site inspection approval of any facility. No discharge of any wastewater or sewage shall be permitted before such a final on-site inspection.

51. The Agency shall assure that all effluents are treated at least to primary treatment standards and as otherwise may be necessary, on a site-specific basis, to protect public health and to suit the particular receiving environment.

<u>Comment</u>: As site-specific information becomes available, the Agency may wish to modify the discharge requirements, particularly when it appears eminent that harm to the environment will occur. This may take the form of changes in specific limits or up to the point of terminating the discharge.

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SOLID WASTES: CAMPS AND FACILITIES

GENERAL RECOMMENDATION

The Company shall develop and implement methods of handling and disposing of solid waste from camps and facilities that protect the health and well-being of the resident human population and protect the physical and living environment to the limit of existing technology and reasonable cost.

The government should ensure that the effect of all approved solid waste plans are responsive to public health standards and are responsive to the particular receiving environment.

DISCUSSION

The two objectives of a solid waste management scheme are: (1) to protect public health and (2) to minimize the environmental impact of any disposal operation. Standard, well understood procedures exist to help meet the first objective but the particular nature of the pipeline project and the northern environment makes it difficult to use a standard approach to meet the environmental objective.

Permafrost and low temperature along the proposed route severely limit and, in many cases, preclude, the use of conventional sanitary landfill and other standard techniques.

The construction project will see large volumes of diversified types of solid waste produced over a short period from centres of activity spread over a vast area. Wildlife, particularly bears, foxes and rodents, will be attracted to the waste unless it is properly handled and treated. Improperly treated waste could pollute, both aesthetically and biologically, the relatively pristine northern flora and fauna.

Both pipeline companies plan to deal with solid wastes from camps and facilities in the same way (they both used the same consultant). Generally, incineration is proposed with non-combustible waste being stockpiled for return to previously designated areas or for burial. It is suggested that sanitary landfill would be used in non-permafrost areas. Site-specific details are lacking and will not be available before final design.

The problem that poses most concern with respect to domestic solid waste is the attraction it offers to wildlife. The only effective measure to decrease this problem is the proper handling of waste at its source with final disposal by incineration.

RECOMMENDATIONS: THE COMPANY

The Overall Plan

1. Before final design and before site-specific approvals are granted, the Company shall prepare an Overall Plan for solid waste as specified in sections 1 and 2 of Wastewater and Sewage.

The Site-Specific Application

2. A separate application must be filed with the government for solid waste disposal for each construction spread and each camp or facility that has an annual manpower requirement of 200 man days or more. Application for camps or facilities with manpower requirements of less than 200 man days may be grouped provided the activities for each are within the same three month period.

3. Each application shall be keyed to the Overall Plan.

4. Each application shall include the details as outlined under Wastewater and Sewage (section 5) and each application shall apply only as noted therein (section 6). Also, applications for disposal sites shall include an evaluation of topography, soils, substrata, ground and surface water conditions, high water level of nearby streams, availability of fill material and rehabilitation measures to be used upon abandonment.

5. In all circumstances, the burden of proof for demonstrating the effect of disposal of a solid waste shall rest with the Company.

Qualified Personnel

6. The Company shall designate a responsible individual fully conversant in all aspects of solid waste practices and operation of related equipment at each location of activity and shall designate sufficient staff and equipment to implement the approved solid waste management plans.

Waste Handling

7. The Company shall adhere to the "Code of Good Practice for Handling Solid Wastes at Federal Establishments" as published by Environment Canada unless it is demonstrated to the Agency that other practices are preferable.

8. All domestic solid waste from meals or other activities along the right-of-way or elsewhere away from the designated camp or permanent facility shall be incinerated immediately on location or stored in tight fitting animal proof containers for shipment to the nearest approved disposal facility within 12 hours or at the end of a work shift, whichever is sooner.

9. Sewage sludges and sludges resulting from the treatment of water shall be handled according to methods developed by the Company and approved by the Agency at each location. (See Recommendation 14 below)

10. Scrap metal, oil drums, discarded equipment and other metallic and non-flammable waste shall be stored temporarily in designated areas. Volume shall be reduced by compaction, and the material shall be transported to previously designated and approved disposal or storage sites unless the Company can demonstrate that other methods of handling are preferable.

Incineration

11. All combustible waste shall be incinerated in an approved incinerator unless the Company can demonstrate, on a site-specific basis, that other means of disposing of the waste are preferable.

12. Open burning shall be prohibited except with prior written authorization of the Agency.

13. Emissions from incinerators shall meet all the requirements as outlined in "Air Pollution Emissions and Control Technology, Packaged Incinerators" (McColgan, I.J., 1976).

14. Sewage sludge from treatment plants shall be dewatered and incinerated unless the Company can demonstrate, on a site-specific basis, that other means of disposal of the waste are preferable.

Disposal Sites

15. Solid waste disposal sites shall be located at least 1000 feet from watercourses, human settlements or camp sites and shall be situated to avoid contamination of any stream, lake or groundwater system.

16. Solid waste disposal sites shall be in accordance with the "Code of Good Practice on Dump Closing or Conversion to Sanitary Landfill at Federal Establishments" as published by Environment Canada, unless the Company can demonstrate that other practices are preferable.

17. Borrow pits to be used as solid waste diposal sites shall be so designated on the application to use the borrow pit materials.

18. Hazardous or toxic wastes, such as solvents, oils, lubricants, greases or radioactive wastes, shall be excluded from normal landfill operation unless specifically approved by the government. (See also "Solid and Liquid Wastes: Construction/Industrial Activities.")

19. Storage areas and disposal sites shall be adequately fenced to prevent access by scavengers such as bears, foxes, wolves and wolverines, and to contain wind blown rubbish.

20. Upon completion of disposal operation at a particular site the Company shall revegetate and grade the area to suit the local natural topography and drainage characteristics and shall post permanent signs that indicate the extent of the abandoned site and its dates of use.

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SOLID AND LIQUID WASTES: CONSTRUCTION/INDUSTRIAL ACTIVITIES

GENERAL RECOMMENDATION

The Company shall dispose of solid and liquid wastes resulting from pipeline construction and related industrial activities in an aesthetically pleasing manner that minimizes the direct and indirect effects on the physical and living environment.

DISCUSSION

Solid and liquid wastes resulting from construction and related industrial activities on a project of the scale of the proposed pipeline present problems because of their volume and generally inert or toxic nature. These problems will be compounded on the project in the North because of the remoteness and vast area of the operations, the pristine nature of the environment and the severe climate. Special measures and diligence by the Company and the government will be necessary to implement an effective waste program.

The current practice of stockpiling scrap metal, machinery etc. in designated areas will have to be greatly expanded for the massive pipeline project. Disposal of other construction and related industrial solid and liquid wastes will have to be addressed on a site-specific basis bearing in mind that the objective of all such programs is to leave the site of all activities in a safe and aesthetically pleasing condition.

Disposal of surplus excavated material (soil and rock) will pose special problems. If the material has a high ice content, spring thaw could cause erosion or could jeopardize the revegetation/rehabilitation program. Also, it is likely that significant volumes of excess excavated material will result from cut banks at river and stream crossings and will have to be disposed of in a way that will avoid siltation of the waterbody.

RECOMMENDATIONS: THE COMPANY

Overall Plan

1. As part of final design and before final approval is granted, the Company shall prepare an Overall Plan for the handling and disposal of construction and industrial solid and liquid wastes (as specified in "Wastewater and Sewage", recommendations 1 and 2).

Site-Specific Application

2. An application for disposal of construction and industrial solid and liquid wastes shall be submitted with the application for solid waste disposal at camps and facilities.

3. A separate plan for disposal of construction and industrial solid and liquid waste shall be prepared for each construction spread and shall be keyed to the Overall Plan.

4. Each application shall include details as outlined in recommendation 5 "Solid Waste: Camps and Facilities", and shall apply as noted therein.

5. In all circumstances, the burden of proof for demonstrating the effect of a discharge of waste shall rest with the Company.

Hazardous and Toxic Wastes

6. Hazardous and toxic wastes, X-ray wastes, radioactive wastes, etc. shall be listed in the site-specific application and shall be specially highlight as such. Each application shall specify for all hazardous and toxic wates associated with activities included in the application:

   (a) the name, properties and use of each substance;

   (b) the volume of waste;

   (c) the toxicity data for each substance (if available);

(d) the propsed method of packaging, transporting, transforming and stowing of the waste; and

(e) the proposed method of disposal.

Comment: The term "Hazardous and toxic wastes" includes any product or substance that is or contains a poisonous, toxic, inflamable, explosive or corrosive product or substance of similar nature which upon release or escape to the environment may cause or may contribute to a harmful effect on the environment and on human health and safety. It covers chemical, toxic, hazardous and similar gaseous, liquid and solid wastes but excludes liquid and solid municipal wastes, pathological wastes, non-toxic and non-hazardous commercial and industrial solid waste, construction debris and similar wastes. (also see "Spill Prevention and Control")

7. Substances used on the project shall be selected as much as practicable according to their least toxicity and persistence of their waste product in the living environment.

Qualified Personnel

8. The Company shall designate waste management personnel as noted in "Solid Waste: Camps and Facilities".

Waste Handling

9. The Company shall manage all solid waste as noted in "Solid Waste: Camps and Facilities", recommendations 7, 8, 9, and 10.

10. All hazardous and toxic wastes associated with the project shall be handled in compliance with the "Code of Good Practice for Management of Hazardous and Toxic Wastes at Federal Establishments" (EPS, Environment Canada).

11. Non combustible construction and industrial solid wastes such as scrap metal, discarded equipment etc. shall be stored temporarily in designated fenced areas and, if possible, reduced in volume by compaction.

Waste Disposal - General

12. All combustible construction and industrial solid waste shall be incinerated as specified in "Solid Waste: Camps and Facilities" unless the Company demonstrates that other disposal methods are preferable.

    Comment: Some comubstible waste emanating from construction activities such as waste lumber, paper, paper products etc. may be allowed to be buried in a sanitary land fill operation with the prior written authorization of the Agency.

13. Trees and shrubs rendered as waste from clearing or cutting shall be burned or chipped (see "Vegetation Clearing").

14. All non-combustible construction and industrial solid waste such as scrap metal, discarded equipment and parts, pieces of pipe etc. shall be transported to designated storage/disposal areas unless disposal by other means such as burial in worked out borrow pits is approved by the Agency.

15. If a borrow pit is to be used as a disposal site for construction/industrial solid waste it shall be so designated in the initial application to use the borrow pit and shall be so approved by the Agency. (See "Borrow Operations").

16. Solid waste disposal sites shall be located and operated in accordance with the requirements of "Solid Waste: Camps and Facilities" (Recommendations 15 to 20).

17. All hazardous and toxic wastes shall be disposed of in a manner specifically approved by the Agency and in accordance with the "Code of Good Practice for Management of Hazardous and Toxic Wastes at Federal Establishments".

Waste Disposal - Excavated Materials

18. An undisturbed area of natural vegetation at least 300 feet in width shall be left between any disposal site containing waste soil or excavated material and any waterbody or any public right-of-way.

19. Waste soil, rock and other materials resulting from operations on the right-of-way shall not be disposed of in any waterbody, ice covered or otherwise, unless specifically approved by the Agency.

20. Construction wastes consisting of waste soil from the pipeline trench or other excavations, stumps and other excavated residue should be disposed of in designated borrow pits. Alternatively, soil may be disposed of by spreading over the right-of-way if the Company demonstrates that such a practice would not cause siltation of adjacent waterbodies, interfere with natural drainage, local vegetation or the right-of-way revegetation program.

21. Spreading of waste excavated material on the right-of-way shall not be in layers greater than six inches and shall not be on slopes greater than three degrees.

22. Small amounts of waste organic material from excavations may be spread out on cleared areas provided it is spread in layers not exceeding six inches and is covered with soil or otherwise rendered harmless as a fire hazard.

23. Where the amount of waste soil exceeds the capacity of the designated borrow pits and/or right-of-way, the waste soil may be disposed of in spoil mounds. Plans for disposal in spoil mounds shall be prepared by the Company on a site-specific basis, and shall include details on:

(a) the clearing and stripping of topsoil;

(b) topography and drainage before and after the disposal occurs;

(c) the nature of the substrata;

(d) the properties of the soils or other excavated material to be disposed of at the site;

(e) the height, side slopes and drainage features of the spoil mound; and

(f) rehabilitative measures including grading and revegetation.

24. Disposal of thaw-unstable (ice rich) excavated material shall be completed before such material has deteriorated from its in-situ condition.

25. Thaw-unstable excavated material shall be disposed of only in designated worked out borrow pits in a manner approved by the Agency. Disposal of such material shall be included in the borrow pit rehabilitation/revegetation scheme in such a way that it will remain stable.

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WATER SUPPLIES AND INTAKES

GENERAL RECOMMENDATION

Removal of water shall be permitted only where and when such a withdrawal and the associated works and activities will not adversely affect:

(a) other uses of the water source for domestic, industrial or recreational purposes; transportation or access to the waterbody; or trapping or fishing by local people;

(b) fish population and other aquatic biota in the waterbody; or

(c) waterfowl or wildlife utilizing the waterbody or its margins.

DISCUSSION

Water withdrawals for the construction of the pipeline project will be substantial. Arctic Gas estimates a total water requirement for construction camps, testing and snow roads of 742 million Imperial gallons (exhibit 452, 453 and 497). The largest use of water is for snow roads and ditch flooding (Williams, 52:7007).

The use of snow making equipment to build snow roads and a working surface along the right-of-way will require an estimated 1.8 million Imperial gallons per mile (Williams 131:19929). Water requirements for testing the big inch pipe will be substantial whether a water-methanol solution medium or a warm water medium is used. Hence, the routing of the pipeline and the construction methodology employed will have a direct bearing on the water withdrawal requirements.

There appears to be enough water along the entire length of the pipeline to fulfill the needs of the project and the environment provided that local precautions are taken. Some shortages could result from construction activities during low flow periods and along the Yukon North Slope. This could create significant conflicts between the needs of the project and the living aquatic environment.

Removal of water by lowering the level or reducing the flow in watercourses can have adverse effects on fish and wildlife as well as on a variety of the activities of man. In addition, the operation of water intakes and the construction of associated works can compound these adverse effects. Water removal for the project will be at a maximum during the winter months when the aquatic life are very susceptible to changes in flow. Therefore, the principal concerns over water removal that are distinctive for this project relate to the potential effect of winter activities on fish, bearing in mind the large number and geographic diversity of the water sources that will be tapped.

Fish are dependent on maintenance of critical water levels and/or flows in the areas and at the times used for migration, spawning, rearing and other site specific elements of their life cycle. Overwintering of fish and eggs in streams with a limited flow and in streams or lakes with a limited depth of water below the ice are particularly dependent on the maintenance of the flow and depth Thus fish could be affected by water removals for the pipeline project.

Aquatic furbearers could also be affected by water removal and if reduced water levels persisted into the summer it could be detrimental to waterfowl and shoreline wildlife.

In view of the above, water use by the pipeline project could be of some concern relative to fishing and perhaps to local trapping. Concerns over water removal in relation to transportation, or access to waterbodies, recreational use of waterbodies, or domestic water use are expected to be limited but may arise in some places.

The magnitude of the water requirements and number of sources that will be used will require the most diligent planning and control. While current practice on such matters should, by and large, be continued, some special requirements will have to be implemented to assure that the intent and specific requirements of current legislation are met.

RECOMMENDATIONS: THE COMPANY

Overall Plan

1. Before final design and before site specific approvals are granted, the Company shall prepare a general Overall Plan for all water withdrawals (as specified in "Wastewater and Sewage: Camps and Facilities").

2. The Overall Plan shall specify:

   (a) the source of all waters;

   (b) the proposed method of withdrawal, means of transportation storage, treatment and use of the water;

   (c) the anticipated volume, rates and periods of withdrawal;

   (d) the general physical and biological characteristics and domestic and/or commercial utilization of the water source; and

   (e) alternate sources that could be used if the proposed site is unacceptable to the Agency or if the proposed site has to be excluded for any reason during the proposed withdrawal period.

Site-Specific Application

3. A separate and site-specific application shall be filed by the Company for each water withdrawal regardless of its rate or duration except a group application shall be permitted where two or more withdrawals are from the same waterbody, occur during overlapping periods and are for similar volumes each of which is less than 5% of the minimum daily flow or total volume of the source.

4. Each application for water withdrawal shall be keyed to the Overall Plan and shall be submitted at least one year prior to the withdrawal if the withdrawal is for snow road construction, pipe testing or ditch flooding.

5. Each application shall comply with the requirements of the section on Fish and shall specify:

   (a) the source of the water and location of use;

   (b) the maximum rates of withdrawal and the total volume to be withdrawn or the volume per unit of time in the case of an ongoing withdrawal;

   (c) a statement justifying the need for water and the selection of the withdrawal site to meet this need;

   (d) the intake, transportation and treatment design details for the water withdrawal works;

   (e) the particular environmental and land use characteristics of the water supply source (including its use by fish, wildlife, trappers, fishermen or any other people for recreational, professional or any other reason) together with the Company's assessment of effects of the proposed withdrawal; and

   (f) the physical changes to the waterbody that will result from the withdrawal including;

      (i) Watercourses: percent decrease in flow rate and water depth and water level. For winter withdrawal where fish or eggs are present downstream, change in depth and area of pools during minimum flow and maximum ice cover;

      (ii) Lakes: percent decrease in water volume and maximum water depth and water level, and time when water will recover its natural level.

6. Applications that are approved shall be valid only for the quantities, locations and periods of withdrawal specified in the approved application. If the aforementioned are altered in any way that would increase or change the location of the impact, the Company shall submit an ammended application for approval before any such change occurs.

7. In all circumstances, the burden of proof for demonstrating the environmental effect of a water withdrawal shall rest with the Company.

Design Considerations

8. All water withdrawals shall be in accordance with site-specific plans prepared by the Company, signed and sealed by a professional engineer and approved by the government.

9. The design of all water withdrawal facilities shall be in accordance with the following parameters:

   (a) Water shall not be removed from a waterbody frequented by fish, waterfowl, or aquatic fur bearers unless the applicant has demonstrated that this water-use will not be detrimental to the fish, waterfowl, or aquatic fur bearer populations and resources in and around the waterbody, either at the time of removal or at other (subsequent) times. If the Company submits that a waterbody is not frequented by fish, etc., it is responsible for demonstrating the veracity of this submission.

   (b) A water intake shall not be located within 200 yards of fish spawning or overwintering areas which have well-defined boundaries. Water removal from large watercourses having scattered overwintering and spawning areas shall be permitted if proper screening and approved velocities are maintained.

   (c) Water removal shall not exceed 10% of the minimum quantity of water in the waterbody during the period of removal. In any case, water shall not be removed from any lake containing fish unless it is deeper than 12ft, or from any flowing waterway where removal would reduce velocity below 1.5 ft/sec. or depth below 6/10 ft. In all waterways containing fish, the flow rate shall be maintained at least at the median monthly minimum flow level during November - April. The monthly minimum flow calculation shall be the flow normally expected in streams and 9 out of 10 years during each of the winter months.

   (d) Water removal shall not cause siltation or turbidity in excess of standards set out in the section "Suspended Sediment Standards in Waterbodies."

(e) The intake structure shall be located and designed so that the maximum inlet velocity is 1 foot per second and so that the intake avoids interference with indigenous fish populations assuming a worst case situation for ice build-up on the screen and in the water source.

<u>Comment</u>: Intakes may have to be recessed into a stream bank to avoid adverse effects to migrating juvenile fish.

(f) Stationary intakes shall conform to the specifications outlined in the Intake Screen Guidelines (1972) of the Fisheries and Marine Service (Vancouver), Environment Canada.

(g) Movable intakes shall be assessed and approved on an individual basis but should meet specifications comparable to those for stationary intakes.

10. The design shall include measures that will be taken during use and upon abandonment to stabilize the affected approaches to the source so that creeping and erosion will not occur.

11. Where permanently submerged water withdrawal structures are utilized, the Company shall arrange an on-site inspection of the structure prior to its installation.

12. The Company shall design all water related systems for construction activities, camps or permanent facilities incorporating practices and hardware to minimize the use of water. This will be particularly important in areas that are ecologically sensitive or are without an abundant water supply.

<u>Operating Considerations</u>

13. A qualified individual for water withdrawal shall be at the water withdrawal site at all times during withdrawals of water used for industrial and related operations during pipeline construction and testing; (ie. pipe testing, ditch flooding, snow road construction).

14. A qualified individual for water withdrawal shall be a person who has been so designated by the Company and approved by the government and who has a demonstrated knowledge of:

    (a) the critical biological features of the water supply source including the habitat features that must be protected and the presence and movement of fish;

    (b) the design and operation of the water withdrawal facility; and

    (c) safety.

15. The qualified individual for water withdrawal shall be given authority by the Company to stop all water withdrawals should it be asked to do so by the authorized officer on-site or should he deem it necessary to do so on the basis of his own judgement.

16. If an intake impairs fish habitat or movements, directly or indirectly, it shall be shut down and then redesigned or moved to a more suitable location that has been approved by the government.

17. If the minimum flow or depth in the watercourse or lake is approached during water withdrawal, the extraction of water shall cease until a safe water level is restored.

18. Upon abandonment of a water withdrawal facility or where such a facility will not be used for one month or more, the Company shall remove the intake and all related equipment and structures from the water.

RECOMMENDATIONS: THE GOVERNMENT

19. Site specific plans for each water withdrawal site should be approved by the government prior to allowing the Company to commence any on-site construction activity.

20. Approval of site-specific plans by the Agency shall be conditional on a final on-site inspection approval of the water withdrawal facility. No water withdrawal should be permitted before such a final on-site inspection.

21. The Agency shall not approve any water withdrawal scheme unless the Company demonstrates that the water use and the associated works and activities will not adversely affect other uses of water for domestic or industrial purposes, transportation on or access to the waterbody, or trapping and fishing by local people.

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PIPE TESTING

GENERAL RECOMMENDATIONS

The Company shall apply high standards of quality control during construction of the pipeline, in order to minimize the risks of pipe failure during field testing, and the resulting problems associated with repair or replacement of any segment of the pipeline.

The Company shall carry out all field testing of the pipeline in an environmentally safe manner. The whole testing procedure, including water withdrawal and test medium disposal, shall be subject to a permit from and closely regulated and inspected by the Agency.

The Company shall develop detailed contingency plans for the containment and removal of any testing medium spilled as a result of any failure of the pipeline or of the testing process and procedures. In particular, the Company shall ensure that no waterbody is contaminated with a toxic pipe testing medium.

DISCUSSION

This section deals primarily with the measures required to ensure that the impacts of pipe testing and the handling and disposal of the test medium are minimized to the greatest extent possible. Detailed discussion of the impacts of and recommendations to control the problems associated with the taking of the large quantities of water required for pipe testing will be found elsewhere in this report, the key section being "Water Supply and Intakes".

All pipelines have to be field tested for strength and leaks before they are put into service. The testing is done, section by section, after the pipe trench has been backfilled. The usual method is to fill the pipeline with water and apply a hydrostatic pressure. If any part of the section under test fails, the failed segments have to be excavated and replaced. The pipeline is also tested for any dents or deformities, and again segments that do not meet the specifications have to be replaced.

Since the pipeline is to be built and tested in winter, water itself is unacceptable as a test medium. Water freezing in the pipe during testing would invalidate the test, damage the interior of the pipe and possibly cause it to fail. Two main methods of overcoming this have been proposed. One is to heat the water and, by passing warm water through the pipe prior to testing, warm up the pipe and the backfill sufficiently to prevent any freezing during the actual test. This method requires the use of substantially more water than the volume needed for the actual test, uses a large amount of fuel and presents the problem of disposing of large quantities of warm water. The other method is to mix a freeze-depressant with the water to give a solution that will not freeze during the test. The antifreeze chemical contemplated is methanol, commonly known as wood alcohol. This method uses much less water than testing with warm water, but presents the problem of disposing of large quantities of a toxic liquid. Depending on the ground temperature, the air temperature and the distance between the water source and the segment of pipe under test, the concentration of methanol will vary from a few percent up to as much as 40% by volume.

The present field pressure testing plans of Canadian Arctic Gas and Foothills are quite different. Canadian Arctic Gas proposes to use water in non-permafrost areas, warmed as necessary to allow for winter temperatures. In permafrost areas, it proposes to use a water-methanol mixture, with a methanol concentration of not greater than 26% by volume. Foothills presently proposes to use water, heated as necessary, for all of its pipeline except parts of Spread 2 (MP 89-187, Campbell Creek to Thunder River), where a water-methanol solution will be used since suitable water sources are lacking. The solution may have to be hauled by tank truck for some distance, and to prevent it freezing in the tanks, the methanol concentration may be as great as 40% by volume.

Apart from water withdrawal, several aspects of the pipe testing plans have a potential for causing or leading to undesirable environmental impacts. Some of these can be avoided through the rigorous application of quality controls during construction. The others cannot be avoided if the project is to go ahead. Hence the objectives of these terms and conditions is to reduce the impacts to an acceptable level. Five main areas of concern have been identified.

First is the problem of withdrawing large quantities of water in winter time, and its potential impact on fish populations and aquatic habitat. This concern is discussed in "Water Supply and Intakes".

Second are the risks of contamination of the environment, and waterbodies in particular, with a concentrated solution of methanol should the pipe fail during the pressure test. An associated problem is that of spillage of methanol during movement, presumably by tank truck, from the stockpile area to the work site. In this case, although the spilled liquid could be 100% methanol, the quantity spilled will be limited. As methanol is quite volatile, the problem of small spills (a few pints to a few gallons) during the loading and unloading of tank trucks is not considered serious.

The third area of concern is the impact of containment and clean-up of spilled methanol or water-methanol solution should a tank truck be involved in an accident or should the pipe fail. The clean-up procedure could result in considerable disturbance of the ground surface, leading to erosion problems. A related problem is the disturbance that would result from excavation and replacement of a segment of pipe that either failed the pressure test or had suffered some deformation during installation and backfilling.

A fourth subject of concern is that the spent test liquid will have become contaminated with toxic materials from inside the pipe -- materials such as corrosion inhibitors and welding residues. This is of particular concern in the case of tests done with water, for the used water may be discharged directly to the environment with no opportunity to remove such contaminants.

Finally, there are the problems associated with the discharge of the used test liquid, whether warm water or water-methanol solution. Careless discharge of very large quantities of water during winter even at the modest temperatures involved (+1 to +3°C), can seriously disturb the hydrological regime and thermal balance of the receiving waters, and so disturb the aquatic life. This problem also arises during the process of warming the pipe prior to testing or if the pipe should fail during the test. With regard to the disposal of water-methanol solutions, both Canadian Arctic Gas and Foothills propose to use the same procedure. The testing solution is to be distilled, producing a distillate of about 70% methanol which is to be reused or burned in an

incinerator. The residue from the distillation process is to be diluted to a concentration of not greater than 1% methanol and discharged to the environment by being spread on snow covered land surfaces or frozen water courses. It was also suggested that the 1% methanol solution could be disposed of directly into large waterbodies, provided it was discharged at a rate which would provide sufficient dilution in the receiving waterbody.

Both Canadian Arctic Gas and Foothills propose to re-use the water-methanol test fluid many times, and to store it from one construction season to the next for further use. Three methods of storage have been proposed: in steel tanks, in bladder tanks or in completed sections of pipeline.

Detailed discussion of the problems of shipping, handling and storing methanol prior to its actual use in the testing procedure will be found in "Spill Prevention and Control". Discussion of the actual impacts of spills of methanol and water-methanol solutions on the aquatic environment will be found in "Fish Protection".

The actual impacts of pipe testing, particularly should the pipeline or the testing procedures fail, are site-specific. However, it is not possible to predict the locations at which problems are likely to occur. Therefore the recommendations are aimed at ensuring the development of procedures to minimize the likelihood of any problems occurring, and to minimize the impacts of such problems and the unavoidable impacts associated with disposal of the test medium.

Detailed discussion of the impacts of repairing or replacing a segment of pipe will be found in "Emergency Repairs to the Pipeline and Right-of-Way".

RECOMMENDATIONS: THE COMPANY

1. In order to minimize the risks of pipe failure during field testing and the resulting problems associated with repair or replacement of any segment of the pipeline, the Company shall rigorously apply high standards of quality control during construction of the pipeline.

In particular, special attention shall be paid to the reliability of all welding and the testing of welds, to the pipe laying operation and to the backfilling operation, including the placement of any bedding and padding materials necessary.

2. The Company shall submit detailed plans for field pressure testing for the approbation of the Agency.

3. In addition to complying with the requirements of the Gas Pipeline Regulations (National Energy Board, 1974) and C.S.A. Standard Z184-1973, pipeline testing will only be carried out under a permit from and in the presence of a representative of the Agency. Each pipe test segment shall be covered by a separate application to the Agency, accompanied by:

   (a) The location or locations at which each of the following operations are proposed, details of the equipment and procedures proposed to be used, of the quantities and temperatures of water and methanol involved, and of the dates and times of the proposed operations:

      (i) water withdrawal (also see "Water Supplies and Intakes"),

      (ii) any pretreatment of the water, nature of residue and plans for disposal of residue,

      (iii) the heating of water and the filling of the test section or sections,

      (iv) the mixing of methanol with the water and the filling of the test section or sections,

      (v) the storage of water or water-methanol solution in the pipe between tests or from one construction season until the next,

      (vi) the emptying of the test section, and

      (vii) the disposal procedures for the test medium.

(b) Details of site-specific contingency plans for each test section outlining methods of containment and recovery of spills of warm water, water-methanol or pure methanol, should the pipe or any associated equipment fail during testing, including methods of detection, notification, decision-making, containment, countermeasures, clean-up, disposal of warm water or water-methanol solutions and restoration, which adequately reflect concerns for vegetation, surface waters and wildlife habitats and which meet with the approval of the Agency, and including the specific locations of all catchment devices that will be built to keep spilled fluid out of waterbodies.

(c) A thorough biological and hydrological inventory of each site proposed for use during pipe testing procedures, together with an environmental impact report of the operations proposed, and including a discussion of the seasonal implications of the operation.

(d) Any other information required by the Agency.

Comment: The repair of any pipe that fails during testing shall depend on the availability of snow road access to the site of the failure. No extension of the construction season will be permitted for the repair of any section of pipe that fails during testing.

4. Repair or replacement of any segment of pipe shall comply with the recommendations set out in the section on "Emergency Repairs to the Pipeline and Right-of-Way".

5. The Company shall not use machinery or otherwise conduct the testing operation so as to harass or unnecessarily disturb or damage fish or wildlife or their habitat.

6. Water withdrawal for pipeline testing shall comply with the recommendations contained in "Fish Protection" and "Water Supply and Intakes".

7. The test liquid effluent must meet effluent criteria outlined in "Wastewater and Sewage: Camps and Facilities" and "Solid and Liquid Wastes: Construction/Inudstrial Activities". The treated effluent must also meet the criteria outlined in "Water Quality".

<u>Comment</u>: The potential toxicity of the effluent from pipe testing operations is a serious concern, and must be investigated before any effluent is dishcarged. Toxicity of the effluent to fish should be determined by a bioassay test. The procedures for the test should be specified by the Toxicity Coordination Committee of the Environment Protection Service, Department of the Environment, and should include similar provisions to those outlined in the "Petroleum Refinery Effluent Regulations and Guidelines" (EPS/DOE, 1974).

The preferred methods of disposal will be direct incineration or distillation, with the distillate burned or used. Subject to site-specific studies, the residue could be disposed of by being:

(a) diluted to a 1% solution and metered into a flowing watercourse;

(b) stored in a lagoon until natural or mechanical processes have reduced the concentration to an acceptable level, and the resulting solution discharged directly into a flowing watercourse;

(c) diluted and sprayed in a controlled fashion onto a vegetated land surface, at a rate that will not exceed the assimilative capacity of the area; or

(d) diluted and sprayed in a controlled fashion onto a snow covered vegetated land surface or onto a large ice covered waterbody where sublimination, evaporation, dilution and biological degradation of the solutions are demonstrated to be within the assimilative capacity of the area. Spraying onto ice that is cracked, rotted or contains holes shall not be permitted.

8. The Company shall dispose of all test liquids, including the water used to heat the pipeline by treating it to reduce concentrations of oils, organic carbon compounds and particulates to acceptable levels before dishcarge.

9. Where a methanol solution is disposed of by spraying onto land or ice covered water, the Company shall specify the method of controlled spraying, the rate of spraying, the total load to be applied per acre, and all the environmental and other information used by the Company in developing the proposal.

10. The Company shall store water-methanol test fluid from one construction season to the succeeding season in steel tanks or bladder tanks in accordance with the recommendations described in "Spill Prevention and Control". Test fluids stored in completed sections of pipeline shall only be stored in sections which have been successfully pressure tested and have been approved by the Agency for storage purposes.

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SPILL PREVENTION AND CONTROL

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SPILL PREVENTION AND CONTROL

GENERAL RECOMMENDATIONS

The Company shall take every precaution to prevent spills of fuels, chemicals and other environmentally noxious substances which will be used during the construction and operation of a Mackenzie Valley pipeline. The Company shall ensure that hazardous substances are transported, transferred, stored, used and disposed of in manners that include best known methods presently being practised elsewhere. Improvements shall be incorporated wherever necessary to better protect the environment. An early commitment to a stringent spill prevention program shall be made by the Company in order that hazardous material handling equipment can be specially designed, and personnel thoroughly trained to ensure maximum spill prevention.

The Company will be expected by government to have an appropriate emergency organization to deal with any spills of fuel or chemicals which might occur during the construction and operation of a pipeline through the Mackenzie Valley. Such an organization shall have a workable written contingency plan which spells out how a spill emergency would be handled in the vicinity of the pipeline right-of-way and in areas downstream which could be affected.

In order to ensure that a response to a spill is prompt and that containment measures are as effective as possible, each man assigned to the spill teams must be trained to carry out his required role. The Company shall provide this training of pipeline contruction and operation staff.

The success of a spill contingency plan will depend on what equipment and materials are readily available for containment and clean up. The Company shall select equipment and materials which have been proven effective in arctic conditions. Specific plans of attack shall also be drawn up for emergency response to spills from installations in each spread and for accidents which could occur along transportation routes.

Accordingly, the following approach should be taken towards fuel and chemical spill control during construction of a gas pipeline:

(a) Prevention should be the main thrust of a spill control program, since this has the best chance of really succeeding in controlling pollution of the environment. As this is considered the top priority issue, many very specific details are given in these recommendations on prevention facilities and programs.

(b) Since the chances of containing and cleaning up spills on land are good, storage and transportation facilities should be designed, product transfer procedures followed and contingency plans formulated, to give maximum chance of any spill emergency being handled on land.

(c) Once fuel or chemicals enter larger watercourses where containment is unlikely, contingency planning should be oriented to first protecting key aquatic bird, fish, marine mammal and human use areas in the vicinity of the spill.

(d) Emergency spill clean up operations should be carried out where an immediate response should afford the environment some protection from the spilled material. If clean up equipment or activities would do more damage to the environment than the spilled material (e.g. in high ice content permafrost areas, marsh areas in summer, etc.), the areas should be monitored until a more suitable season for clean up, or until natural degradation of the product takes place.

(e) At some spill sites, the Company should consider setting up experimental monitoring programs to develop better clean up techniques and to determine the impact of a spill on the environment.

DISCUSSION

Introduction

A great deal of evidence has been heard about the threat of oil and chemical spills. Arctic Gas has estimated in its Application that about 100 million Imperial gallons of fuel and methanol would be used in the construction of its gas line. Foothills has estimated that about 50 million Imperial gallons of fuel per season will be moved and stored in the construction of its line.

Since these figures are only estimates, it would not be surprising if the final total amounts of fuels and chemicals used are greater than those quoted in the Applications.

Transportation of fuel and chemical supplies will use both existing facilities as well as new ones to be constructed. For example, Arctic Gas states that its system will include existing rail and road networks, the Mackenzie River barge system, air transportation and ocean shipping. Fuel transportation, storage specifications and designs are discussed in further detail in the Application. (CAGPL, Application, 13.a., tabs.1.1, 3.4, 6.4.8). Separate, dyked areas, "sealed" by an impermeable barrier will be used for fuel storage tanks. Small volumes of fuel (up to 1,500 bbl.) will be stored in "bladder tanks"; steel tanks may be used instead of, or in combination with, bladder tanks for larger quantities (up to 5,000 bbl.). Final selection of tank type will depend on several factors, e.g. volume, length of storage time, availability of land. etc.

Tankers (either wheel or track-mounted, depending on terrain conditions) will transport fuel either directly to construction equipment or to tank storage facilities. Smaller volumes of fuel will be stored at right-of-way facilities during operation of the pipeline.

Many expert witnesses testifying during the environment phase of the formal hearings and many people in the community hearings predicted major damages to aquatic birds, mammals, fish and and native peoples' traditional pursuits if spills occur in the Mackenzie River, Beaufort Sea and Yukon coast areas. This threat is real because the volumes of fuel and chemicals used during pipeline construction are very large, the Company must be as prepared as possible to deal with spills.

An overwhelming conclusion reached from the hearings, the technical literature and actual world experience, is that oil and chemicals once in water, are almost impossible to clean up unless exceptionally calm, temperate conditions prevail at the time of the incident. In arctic marine waters and rivers, these conditions are seldom present.

The U.S. Environmental Protection Agency has estimated there have been about 13,000 spills of oil substances occurring annually in the United States since 1970. Fuel spills have occurred during construction of the Alyeska oil pipeline in Alaska.

It is clear, therefore, that the extremely large volume of petrochemicals moved and stored during pipeline construction render spills inevitable, despite the best planning to control the problem.

Limitations of Petrochemical Spill Control Programs

It must be clearly understood by all concerned with the building of a gas pipeline, that petrochemical spills will occur, that the technology for dealing with petrochemical spills is in its infancy and, as a consequence, some level of damage to the environment will result. The lack of effective technology for dealing with spills in, or on, solid and broken ice should be especially emphasized.

When pipeline construction is underway, freight movement on the river will be extremely heavy and require the use of all or nearly all available air and floating equipment. The availability of equipment for immediate emergency will be minimal. Tugs with barges will have to secure their tows safely before they are available for emergency assistance. Thus, contingency planning mobilization to counter an emergency may be slow at the outset and a more serious situation could develop from a comparatively minor incident than might normally be expected.

The remoteness and large distances between centres of activity and supply will seriously affect the efficiency of clean up operations. Communications concerning supplies, refueling, feeding and housing workers, repair and servicing of clean up devices and general equipment will be complicated by these distances.

The following points should be recognized when planning spill control programs for a Mackenzie Valley pipeline:

(a) There will be extreme difficulty in deploying equipment on the broken ice, in cold temperatures, stormy seas, darkness and permafrost conditions experienced in the North.

(b) Containment booms are relatively inefficient in current.

(c) Fuel and chemicals could run under ice or leak through cracks, between blocks and fissures if spilled on ice surfaces.

(d) Barges presently in use on the Mackenzie River for fuel transportation are not uniform. They vary in design, age, size, equipment and layouts of piping and pumping systems. This creates a potential for more spill accidents.

(e) The use of cargo transfer equipment by low skill or inexperienced personnel will increase the likelihood of spills.

(f) The Mackenzie Valley River system is subject to periodic summer flash floods when the river rises in the order of 1"/hour with an attendant increase in current velocity. This affects the ability to deploy equipment and could cause damage to mooring and transfer pipeline connections.

(g) As there are insufficient storage and disposal facilities for picked up spillage along the route, arrangements for such facilities will require careful consideration. Tugs, barges and engaged in clean up vessels cleaning up spilled material at long distances from established centres will require off-loading of spillage and absorbents when their holding capacity is reached or clean up operations will, of necessity, have to be interrupted.

(h) The shallow shores of the Beaufort Sea and low marsh terrain of the Mackenzie Delta will be extremely difficult areas in which to operate spill containment and clean up equipment.

(i) Some 40-50 million gallons of fuel oil will be transported by barges in the short river shipping season, hence there will be heavy use of equipment and probable necessity of transfer operations in fast current and bad weather conditions at any time of the day.

(j) The shallow depth of rivers by late summer will make deployment of clean up equipment impossible or very

difficult in some locations. At this season, fuels and chemicals could be transferred several times from ocean-going transport to shallow draft river barges, to deeper draft river barges and finally to land storage.

(k) Exposed river banks which are often soft mud will make deployment of clean up equipment difficult.

(l) A rapid fall of a river following a flash flood would spread a spill over soft mud on the banks. These areas would be difficult to clean up.

(m) A Mackenzie River current of approximately 3 miles per hour will disperse a spill for an appreciable distance in a short period of time. This will necessitate deployment of equipment, (vehicles, aircraft, boats, etc.) on very short notification of a spill occurring.

Statement of Possible Impacts on the Environment

There are several studies concerning effects of oil and chemical spills on the environment. Conclusions differ widely, and many of the mechanisms involved in chemical and oil toxicity are not understood.

As petrochemical spills may involve different types of compounds, the threat of pollution can be from the slick itself or from the toxic effects of petroleum fractions or chemicals. In the aquatic environment, some hydrocarbons and chemicals float on water surfaces, others settle to the bottom sediments, some are soluble and the many lighter ends evaporate. The most visible effects of a spill on wildlife are on sea birds and waterfowl. Oil will mat the feathers together on birds so they are no longer able to function for flight, water repellency or insulation. The birds generally die by drowning or exposure once this happens. They are also harmed by the direct toxic effects of oil when ingested through preening their feathers in an attempt to rid themselves of contaminants.

There is conflicting evidence on effects of oil on marine mammals. Petroleum product contamination of restricted areas, such as whale calving waters or seal haul-out sites, could cause some impact on populations using these locations.

Effects on aquatic organisms are generally subtle, and might not be visible to the casual observer. Studies have indicated that oil may affect aquatic life forms in the following ways:

(a) direct kill of organisms through coating and asphyxiation;

(b) direct kill through contact poisoning of organisms;

(c) direct kill through exposure to water soluble toxic components of oil;

(d) destruction of the generally more sensitive juvenile forms;

(e) destruction of food resources of higher species;

(f) incorporation of sublethal amounts of oil and oil products into organisms resulting in reduced resistance to infection and other stresses;

(g) destruction of food values through the incorporation of oil and oil products in fishery resources;

(h) incorporation of carcinogens into the marine food chain and known human food sources; and

(i) low level effects that may interfere with any of numerous events necessary for the propogation of marine species and for the survical of those species which stand higher in the marine food web.

Oil can kill salt marsh grasses, marine seaweeds and fresh-water vegetation. This can lead to loss of food and habitat for wildlife and aquatic organisms and, if extensive enough, can result in erosion of sediments normally held stationary by the roots of these plants. Once contaminated, vegetation is extremely difficult to clean. It generally takes 2-3 years or more for well-oiled vegetation to cleanse itself and recover its former productivity.

The biological effects of different fractions of oil on aquatic life may be summarized as follows:

(a) Low boiling saturated hydrocarbons produce anaesthesia and narcosis at low concentrations in a variety of organisms. At higher cencentrations, they produce cell damage and death (aliphatic oxygen derivatives of hydrocarbons such as methanol have the same effect).

(b) Low boiling aromatic hydrocarbons, such as benzene, toluene and naphthalene, are the most toxic fractions of oil to man and animals.

(c) Higher boiling saturated hydrocarbons include compounds that may interfere with the nutrition and communications process in marine animals. This fraction of oil is rich in multi-ring aromatic compounds which include carcinogenic agents.

Chemical spills may introduce toxic or bioaccumulative chemicals (such as methanol or polychlorinated byphenyls (PCB's)), into the environment. The effects of these chemicals upon the biota depend upon the length of time that the organisms are exposed to the chemicals and the amounts introduced into the watercourse. Very low amounts may be detrimental to young fish and invertebrates. Bioaccumulation (the build-up of pollutants in organism tissue) is also a potential probelms with PCB's. However, the full effects are not yet known.

Substances such as chlorine, used for drinking and wastewater treatment, could also present a potential toxicity threat to the aquatic environment.

In addition to the biological effects of petrochemical pollution, numerous non-biological effects also exist and should be considered. These non-biological effects could result in economic or aesthetic impacts to an area, for example:

(a) fouling of boats, wharfs and commercial or domestic fishing gear and other marine structures;

(b) the problem of a hazard to water-using industries such as power stations, gas plants and refineries;

(c) the reduction in recreational opportunities such as boating, swimming and sports fishing. A spill could seriously affect the tourist industry in a particular area for a period of time;

(d) contamination of water supplies; and

(e) the fouling of specific land status areas such as parks, ecological reserves and lands and waters used by native peoples in their traditional pursuits.

Perhaps one of the most damaging spills which could occur during a Mackenzie Valley pipeline project, would be a fuel release from barges or ships along the Beaufort Sea coast or Mackenzie Delta areas. Marine mammal, bird and fish life would be very sensitive to fuel or chemical pollution in these areas. Ice flows could hamper spill control activities and could increase the environmental damage by allowing any spilled material to spread over wide areas.

The spill problem during construction of a gas pipeline is one of significant magnitude because of the very large amounts of fuel and chemicals involved and the poor technology to control spills in northern waters. In combination with other petroleum related development in the western Arctic, long term impact on the living environment could result.

The subject of spill prevention and control is a broad one that requires many in depth stipulations. Existing legislation contains few regulations that are specific. Therefore, the following detailed recommendations for preventing and responding to spill problems are deemed essential at the outset of the project.

RECOMMENDATIONS: THE COMPANY

Overall Plan

1. Before final design and at least 90 days before any submissions are made for site-specific approvals, the Company shall prepare for government approval an Overall Plan for the handling, spill prevention and control of hazardous/toxic substances and petrochemicals to be used during construction, operation and abandonment of the pipeline. The Overall Plan shall be cognizant, by means of overlays or graphic presentations on the same scale, of other Overall Plans as described elsewhere. (See, for example, "Wastewater and Sewage: Camps and Facilities".)

2. The Overall Plan shall outline, in map form, the physical and biological environmental knowledge necessary to adequately protect the living resources along the pipeline corridor. To be useful in emergency spill control situations, the following information must be included:

   (a) waterfowl and seabird concentration areas along the pipeline corridor and transportation routes;

   (b) fish spawning and overwintering areas along the pipeline corridor;

   (c) ocean currents and wave regimes along the Beaufort Sea transportation routes;

   (d) wind conditions along the Beaufort Sea transportation routes;

   (e) ice movement, freezeup and break up dates in the Mackenzie, its tributaries and Beaufort Sea coast;

   (f) locations of water intakes along the proposed corridor, for temporary and permanent domestic (potable) use, as well as those for industry and construction;

   (g) location and times of use for all domestic, commercial and sports fishing sites along the proposed pipeline corridor;

(h) general hydrology of the Mackenzie River and tributaries and any Yukon water courses crossed by the proposed pipeline (i.e. potential spill containment sites should be chosen when this information is available);

(i) locations and boundaries of all existing and proposed parks, I.B.P. sites, bird sanctuaries and other ecological reserves;

(j) locations of all small craft harbours or use areas along the pipeline corridor;

(k) locations of designated floatplane landing and take off areas;

(l) locations of marine vessel docks and landing sites;

(m) locations of settlements and hunting and fishing areas and camps;

(n) locations of archaeological or historic sites which could be adversely affected by spills;

(o) locations of rare and endangered species habitat;

(p) locations of all petrochemical and hazardous and toxic chemical transportation routes, storage areas and their times of use;

(q) volumes of petrochemicals to be moved along various routes and stored at the various locations; and

(r) a list of all hazardous and toxic substances to be used in various specified locations which includes: the name, properties and use of each substance, the volume, the toxicity data (if available), the proposed method of packing, transporting, transferring and stowing for each substance, and the proposed method of disposal.

Comment: "The term hazardous and toxic substance" includes any product or substance that is or contains a poisonous, toxic, inflamable, explosive or corrosive product or substance of similar nature which upon release or escape to the environment may cause or may contribute to a harmful effect on the environment and on human health and safety. It covers chemical,

toxic, hazardous and similar gaseous, liquid and solid substances and wastes but excludes liquid and solid municipal wastes, pathological wastes, non-toxic and non-hazardous commercial and industrial solid waste, contruction debris etc. The Company should be aware of Environment Canada's EPS publication "Code of Good Practice for Management of Hazardous and Toxic Wastes at Federal Establishments. (See also: "Solid and Liquid Wastes: Construction/Industrial Activities".)

3. The Overall Plan shall document spill control plans, facility designs, transport schedules for fuels and chemicals, contingency plans, and all training programs. Documentation shall include:

   (a) specific contingency plan for each spread;

   (b) operation procedural manuals for each spread and for each product transfer terminal and storage facility;

   (c) detailed designs for fuel and chemical storage facilities, product transfer equipment, and transportation vessels and vehicles. Plans for these facilities shall include:

      (i) a summary of the physical and biological environmental conditions in the area surrounding installations;

      (ii) a complete set of detailed engineering drawings;

      (iii) a complete set of operating standards, including such information as volume through-puts, number of operating personnel, period of usage, expected life of the installation, abandonment criteria, environment protection criteria and environment restoration plans; and

      (iv) an outline of inspection and construction requirements for each facility. The Company shall be responsible for coordination of specified inspections with the Agency;

   (d) training programs and schedules for personnel handling hazardous or toxic material; and

(e) the location and nature of areas for disposing of contaminated materials such as earth, natural and synthetic absorbants and driftwood.

4. As the pipeline construction and operations progress, the Company shall provide updates to its Overall Plan for Hazardous/Toxic Substances and Petrochemicals so that the Plan always reflects the most current information.

Spill Prevention from Storage and Transportation Facilities

Comment: Spill prevention is like a safety program. A great deal of training and supervision of personnel on a continuous basis is required to ensure that good spill prevention practices are followed. Correct operation of storage facilities is particularly important. A continuous inspection program of storage facilities is necessary to ensure that they are maintained in good repair.

Spills will occur due to error on the part of operating personnel or from equipment failure. Facility location, design and construction must be such that environmental damage is minimized when spills occur. Since few specific regulations to ensure spill prevention are presently in force, the following recommendations will minimize the likelihood of a spill occurring.

A. Tankfarms

5. Reinforced concrete or earthen dykes shall surround all above-ground tanks for spill containment. Concrete dykes shall be a minimum of two feet (60.96 cm) high, and earthern dykes shall be a minimum of three feet (91.44 cm) high.

6. Dyke heights required shall be as outlined above or as calculated below, whichever is greater:

   1 foot plus capacity of largest tank plus 10% of capacity of all other tanks divided by effective tankfarm area.

   The effective tankfarm area equals overall area surrounded by dykes less tank floor area (excepting the area of the largest tank).

   The above calculation shall be in cubic feet for volume and square feet for area.

7. Permanent tankfarms shall be rendered virtually leak-proof by ensuring a maximum soils percolation rate of 5 x 10-6 cm/sec. This may be accomplished by locating the tankfarms in areas that have suitable natural soils, by importing such soils, or

by preparing a suitable soils mix with additives and lining the tankfarms with the imported or prepared soils. These soils shall be protected with a minimum 10 inch thick cover of gravel to prevent physical damage.

8. Temporary tankfarms shall conform to percolation rate requirements specified for permanent tankfarms. The criteria may be met in the same manner or by use of oil resistant polyvinyl chloride (PVC) or urethane membranes specifically manufactured for the purpose. Membranes shall be protected against mechanical damage by using a 6 inch protecting layer of sand on each side.

9. PVC membranes are structurally brittle below 0°C and shall not be used if in contact with frozen ground. Urethane membranes are short lived and must not be used in installations which have a life of greater than two years.

10. Tankfarms constructed upon permafrost shall be engineered considering:

    (a) insulation of permafrost from the tanks and other structures to ensure that tank contents or structures do not cause melting; and

    (b) soils investigations to ensure that the permafrost will support the loadings placed upon it without settlement or movement.

B. Underground Steel Storage Tanks

11. Underground tanks shall not be installed in permafrost.

12. Underground tanks shall be buried a minimum of three feet, shall be surrounded with a minimum of 12 inches of clean sand and shall be covered with reinforced concrete slabs in traffic areas.

13. Underground tanks shall be constructed to Underwriters' Laboratories of Canada (ULC) Standards S603 and/or S603.1.

14. Permanent underground tanks shall be protected by use of anodes. Test points shall be installed for anode testing.

C. Above-Ground Storage Tank Standards

15. Above-ground shop fabricated tanks shall be constructed to Underwriters' Laboratories of Canada (ULC) Standard S601.

16. Above-ground field fabricated tanks shall be constructed to American Petroleuum Institute (API) Standard 650.

17. In all cases, the Company shall prepare a proposal for government approval for steel type and welding specifications to be used on metal tankage. Specific areas of concern include protection against brittle fracture of steel by specification of a Charpy-Vee Notch impact requirement.

18. Bladder tanks shall be used for temporary storage only. The tanks shall meet Underwriters' Laboratories of Canada Standards or government specifications for their intended use and shall not be used if atmospheric temperatures can be lower than the minimum temperature for usage recommended by the manufacturer. The tanks shall be installed on a bed of sand at least 12 inches thick.

D. Storage in Floating Equipment

19. Storage of fuels and petrochemicals in vessels used for transportation or in any other floating vessel shall be prohibited except at designated wharf locations. All such storage shall be specifically approved by the Agency.

Storage Afloat:

20. The use of floating storage shall be prohibited in ice conditions unless the barges or vessels are fully protected from moving, floating ice and from being held fast in frozen river or sea water. However, special consideration may be given in specific instances for ice strengthened barges or vessels specifically designed for the proposed service with adequate mooring and docks of adequate strength to support the load involved.

21. It is not recommended that barges be used for storage in waters where there is an appreciable current. If the current exceeds three knots, the use of floating equipment for

storage purposes shall be prohibited except for periods which can reasonably be considered to be waiting periods for off loading (three days).

22. Barges or vessels may be used for storage in waters that have no appreciable current, such as lakes, provided that ice condition requirements outlined above are met. The barge shall be surrounded by a floating containment boom. The mooring arrangements shall be checked every 12 hours and a record kept of times checked and mooring arrangement conditions.

23. Daily recordings and reconciliations of cargo tank ullages shall be carried out on all barges or vessels used for floating storage.

<u>Storage Ashore</u>:

24. All dyking requirements for fixed tankage storage shall apply to floating equipment used for storage on land.

25. As the bottom structure of most barges will not be designed to support the weight of full fuel tanks when out of the water, the underside shall be shored in a manner approved by the Agency for the specific vessel used. Care must be taken to ensure that the shores take the load at major structural members, and not at unsupported panels of plating.

<u>E. Drum Storage Areas</u>

26. Drum (full or empty) storage areas shall incorporate a concrete slab or equivalent impermiable ground cover (eg. steel plates) graded so that all leakage collects at one location.

27. The storage areas shall drain to a sump and oil separator in the case of petroleum storage.

28. Specific approval of plans for disposal of other petro-chemicals, hazardous materials etc., shall be obtained by the Company from the Agency.

F. Pipelines and Fittings

29. All barge, vessel and petrochemical facility pipelines shall be of steel or steel alloy material suitable for specialty product service and consist of welded or welded flanged joints of the applicable pressure rating.

30. Valves and other pipeline fittings shall be of forged or cast steel alloy construction suitable for the temperature conditions encountered. There is exception for inside vessel or barge hull valves which may be of cast iron.

G. Location of Storage Facilities and Routing of Petrochemical Transport

31. Bulk storage of petrochemicals shall not be located within three quarters of a mile of waterfowl concentration areas or within 1000 feet of any waterbody. Floating storage is excepted from the latter requirement. Storage sites in the Mackenzie Delta could be located closer than 1000 feet to watercourses, if approved by the Agency.

32. Total capacity at any one site in the Mackenzie Delta shall be limited to the amount of bulk fuel and chemicals actually required to construct adjacent Delta facilities. Storage tankfarms should be located on stable, high, "old Delta' ground.

Comment: The environmental sensitivity of the Delta combined with its low topograph and susceptibility to storm surges, floods etc. make it necessary to very carefully control activities and facilities associated with things like fuels. The potential problem is such that every effort must be taken to avoid the risk of a mishap. Limiting the size of each storage site is one such measure. The Agency may stipulate a maximum capacity for bulk storage areas in the Delta. Generally, the maximum tank size will be limited to approximately 125,000 gallons (equal to about on quarter of a barge load) and only one tank shall be drawn from at a time with all other tanks locked closed.

33. Loading/discharge fuel terminals shall be located downstream of general cargo loading/discharge berths to reduce explosion and fire hazard.

34. Sites for bulk storage and handling areas shall have a maximum surface slope of 2%. Such sites are preferred because of the physical requirements of storage and handling areas. Drainage flow velocities are generally of the order of magnitude to permit control of runoff water.

35. Routing of waterborne petrochemical transport shall not be through large waterfowl concentrating areas or ecological preserves. If possible, routes avoiding waterfowl concentration areas by at least three quarters of a mile shall be used. Considerable research and field work to establish a complete evaluation of living resources such as waterfowl, marine mammal areas, and human habitation sites will be necessary in locating transportation routes. Navigation hazards and practicability of landing and wharf sites must also be considered. The transport routes designed and approved shall be used exclusively.

36. River and ocean transportation of fuels and chemicals shall be subject to the following conditions:

    (a) fuel or bulk chemical cargo movements on a river or in the Beaufort Sea should not begin until the ice situation and attendant level of water and current flow are such as to not hamper containment and spill clean up activities (this date may vary from year to year);

    (b) fuel and bulk chemical cargo movements on a river should be suspended in the event of a rapid change in river water level and/or current; and

    (c) fuel and bulk chemical cargo movements on a river and in the Beaufort Sea should be completed before the danger of entrapment of vessels and barges by freeze up (this date may vary with the year).

37. If petrochemical transportation, transfer, storage, or waste disposal procedures are found, after application, to be unsuitable to protect the environment adequately, they shall be altered. Re-routing of supplies, relocating storage facilities, or redesigning of transfer and disposal equipment may be required.

H. Marine Transporation Facilities

38. Ships or barges used to carry petrochemical products in bulk for this project shall be classed by a recognized international marine classification society, such as American Bureau of Shipping or Lloyd's Register of Shipping, or approved by the Canadian Coast Guard Ship Safety Branch. They shall be built to the appropriate society's or branch's rules, and constructed under its supervision.

39. Subdivision of the cargo tanks shall be to the requirements of the Oil Pollution Prevention Regulations, Amendment dated September 6th, 1973.

40. Operation, construction and outfit shall be to the requirements of the Load Line Regulation.

41. Standard present practice is for fuel barges to also carry deck cargos but in many instances spill prevention fittings and arrangements are incompatible with carriage of deck cargo. This means that existing barges will require modification and new equipment will require different design and arrangements. The Company shall detail design changes that will be made to present practices so as to ensure spill prevention and control.

I. Petrochemical Transfer Areas for Marine Operations

42. A spill guard shall be fitted around the deck perimeter of barges or tankers to contain major spills occurring during transfer operations. A 12 inch high guard is usually adequate, but a greater height shall be required if the deck is cambered, or if the ship usually operates with trim. Drain openings shall be required in this spill guard to prevent the accumulation of rainwater or spray when underway. These openings shall be provided with wooden wedge-shaped plugs, or screwed cap plugs on keep chains, which must be fitted during transfer operations. A strip of deck outside of the spill guard shall be painted white to allow easy visual identification of a flow of liquids over the side.

43. To contain minor spills to a smaller area than the whole deck, other spill guards shall be fitted around the "make-break" connections, tank vents and hose stowage racks.

44. As far as practical the following items shall be grouped together to aid surveillance during transfer operations: loading and discharge manifolds, cargo tank vents, flow meters, level gauges and pump controls.

45. At the loading and discharge manifolds, bolted flanges or quick operating flange-type connections shall be used.

46. Loading and discharge manifolds whether on marine transportation vessels or on land shall be fitted with spill guards of sufficient capacity to contain an amount of liquid spilled from a manifold connection equal to the throughput during the time it takes to stop the flow in an emergency. The capacity shall be determined by the design shut down time. In no case shall a manifold be installed hanging clear over water or land.

47. A positive means of draining the manifold and hose lines shall be provided. This can be achieved by fitting a pump recirculation connection to enable the discharge pump to deliver product back to the ship's tank instead of to the shore facility during discharge operations. Test cocks shall also be fitted to enable the operators to check that the lines are purged before disconnecting the hoses.

48. The complete deck area, and all areas where operations may be carried out during the hours of darkness, shall be adequately lighted. The following minimum levels of illumination shall be provided:

(a) internal spaces such as pump room: 15' candles;

(b) exterior deck at manifolds and pump controls: 10' candles; and

(c) entire exterior deck other than above: 5' candles.

49. For spill prevention and general safety, the following precautions against fire must be taken:

(a) All electrical motors, switches, etc., shall be of a suitable type for use in explosive atmospheres.

(b) All (cargo tank vents shall have flash screens.

(c) A foam firefighting system shall be permanently installed on the deck. This shall be capable of supplying foam to any part of a deck, and have a capacity of 0.11 Imperial gallons per square foot of deck per minute for a total of twenty minutes. (Further requirements are contained in the Fire Detection and Extinguishing Equipment Regulations of the Canada Shipping Act).

(d) Any machinery spaces shall be protected by an automatic carbon dioxide or similar total flooding system. This system shall automatically shut off all ventilation to the affected space in the event of fire. Also, adequate dry chemical fire extinguishers shall be provided and large "No Smoking" signs in languages and/or symbols understood by all people on site, shall be displayed at the gangway, the manifold and at other locations as necessary.

50. Material shall be available on the vessel to soak up any minor spillage contained by the spill guard. The following items are required for this purpose and shall be stowed in a convenient water tight and lockable locker on the deck:

(a) an appropriate quantity of natural or a commercial absorbant material;

(b) an empty oil drum;

(c) plastic garbage bags;

(d) shovels, rakes and brooms; and

(e) rubber gloves and boots.

J. Transfer Point Procedures for Marine Operations

Comment: There are no set transfer procedures set by regulation. It must be understood that there is no substitute for conscientious, well-trained personnel, willing to take the necessary precautions. "Cutting of corners" during operations, in order to save time or effort, invariably increases the chances of an accident and the severity of an accident should it occur.

Continuous training and supervision of work practices is required.

The following operating steps shall be incorporated into procedures which are developed to reduce the possibility of spillage, and to mitigate the effects of spills should they occur.

51. At all times during loading or discharge of liquid products, suitably trained and certified personnel must stand by at both the receiving and discharge points. For tanks 1000 feet from transport unloading sites, the cargo discharge point on the vessel, receiving point on land, and tankfarm receiving point shall all be manned (three people). The person at the receiving facility shall constantly monitor tank level gauges and/or ullages, flow meters and survey tank vents. The person at the discharge point shall remain adjacent to the pump controls and pump recirculation connection. The hoses and "make-break" connection shall also be watched. All personnel shall be fluent in the same language and be equipped with two-way radios for good communication and co-ordination. A supervisor employed by the Company and responsible for the operation shall be present to oversee the whole operation.

52. Berth operators and crew at marine facilities shall be trained and be competent in all vessel and transfer operations including:

    (a) vessel mooring procedures;

    (b) transfer connection procedures;

    (c) shoreside and vessel cargo flow routing, loading phases and system timing details;

    (d) methods for adapting to different mooring and cargo transfer situations expected at the berth/terminal;

    (e) prescribed operating procedures for a particular berth; and

    (f) emergency and contingency procedures and plans for the particular berth/terminal.

53. During operations involving the transfer of product to or from vessels, all plugs in the spill guards shall be in place. If there is heavy precipitation, it may prove necessary to drain any accumulation of water by removing these plugs. If this is done, the transfer operation shall be stopped during the time that the plugs are not in place.

54. Transfer of product shall not be carried out if more than 1 inch of water is contained by the spill guards.

55. When "topping off" the receiving facility, the rate of flow of product shall be reduced. Before disconnecting the hoses, care shall be taken to purge the lines, and check that they are purged, before the connection is broken.

56. Fire prevention regulations such as "No smoking" rules shall be strictly enforced, and adequate fire extinguishers shall be available adjacent to the transfer location. Personnel shall be trained in the techniques of fighting petrochemical/hazardous substance fires.

57. Products shall not be transferred to or from water-borne transport during darkness (or at any other time when visibility is restricted) unless the area is adequately illuminated.

58. In fast-flowing rivers particular attention shall be paid to the mooring arrangements of barges. Mooring lines shall be of adequate strength for the size of the vessel, and four lines should be employed, two forward and two aft. All lines shall use separate cleats or bollards, both on the ship and the shore. The mooring arrangements shall be checked regularly by a watchman (preferably at least once every hour) to ensure that all is in order.

59. In tidal waters, or in waters such as lakes where fast currents are not present, all fuel transportation equipment shall be surrounded by a floating containment boom during transfer of product. This boom could be carried by the vessel, but would normally be stored at the wharf.

60. To keep all Transfer systems in good order, a detailed preventative maintenance schedule shall be implemented which includes the following:

(a) pumps shall be opened up for inspection once every 12 months, preferably at the start of each season;

(b) valves shall be opened up for inspection once every 12 months, preferably at the start of each season;

(c) hoses shall be visually inspected for damage before each use, and once every 12 months, preferably at the start of each season shall be hydraulically tested to a pressure equal to one and a half times their maximum working pressure;

(d) rigging shall be visually inspected for damage before each use, and once every 12 months, preferably at the start of each season shall be statically tested to one and a half times its rated capacity;

(e) alarms shall be tested for correct operation before each use of the system;

(f) gauges and meters shall be visually checked for correct operation at each use;

(g) fire fighting equipment shall be inspected in accordance with Fire Detection and Extinguishing Equipment Regulations of the Canada Shipping Act;

(h) mooring lines shall be visually inspected for damage before each use, and shall be replaced every 24 months; and

(i) floating containment boom shall be visually inspected for damage before each use.

K. Petrochemical Transfer Areas for Land Operations

61. All transfer areas including but not limited to tank truck loading, drum filling and vehicle fueling, shall have spill collection facilities as outlined in the section "Drum Storage Areas".

L. Transfer Point Procedures for Land Operations

62. All transfer points shall be controlled by fast acting valves so that the flow of product can be immediately terminated upon failure of hoses or other equipment, or occurrence of a fire.

63. Transfer operations shall be constantly monitored by personnel who shall be in attendance during the entire transfer period.

64. Statements made in "Transfer Point Procedures for Marine Operations", concerning transfer point illumination, no smoking regulations, fire fighting capabilities, fire extinguishers and relevant points in the preventative maintenance schedule shall apply.

M. Waste Petrochemical Handling

65. Top-drainage lubrication oil change areas where oil is removed from crankcases by mobile or fixed suction pumps shall not require special protection.

66. Bottom-drainage lubricating oil change areas shall be supplied with concrete slabs or equivalent (e.g. steel plates) suitably graded to a sump and petroleum separator to ensure that any spillage does not contaminate the surrounding area.

67. Spent lubricating oil shall be disposed of by either of two means:

    (a) shipped to a refinery for use as feed stock, or to an oil re-refiner (e.g. Norman Wells); or

    (b) burnt in an incinerator specifically designed for the purpose.

68. Proposals for chemical disposal shall be made to the Agency in each case that disposal is contemplated. A formal approval must be received by the Company before disposal steps are taken. Generally, the disposal shall conform to the "Code of Good Practice for Management of Hazardous and Toxic Wastes at Federal Establishments." (DOE 1976).

N. Contaminated Runoff Control

69. It may not be practical or possible to collect all petroleum leakage and spills at each small petrochemical storage facility in living and work areas. Therefore, runoff water storage pits shall be installed immediately adjacent to these areas to pick up all runoff so that it may be inspected and tested for petroleum content.

70. Storage pit design shall be sized to contain a minimum of 48 hours' water runoff from the area drained. The rate shall be based on the maximum 24 hour runoff rate for the ten year storm return period.

71. In permafrost, pits shall be insulated as required to afford protection to the surrounding soils.

72. Permanent storage pits shall be constructed with soil liners to prevent leakage to the environment. Percolation rates shall be less than 5 x 10-6 cm/sec.

73. Temporary storage pits shall conform to percolation rate requirements specified for permanent storage pits. The criteria may be met in the same manner or by use of oil resistant polyvinyl chloride (PVC) or urethane membranes specifically manufactured for the purpose within the restrictions outlined in the recommendations for tankfarms.

74. Storage pit water shall not be released to the environment until it is ascertained that the oil in water concentration is less than 5 ppm.

75. Surface runoff water from petroleum storage and handling areas will inevitably contain petroleum products. This oily water shall be collected at the source of contamination and transported in closed leak-proof drainage systems to a separator facility.

76. All runoff water from petroleum storage and handling areas shall be drained to a collection pit after treatment in the oil-water separation facility. The pit shall be used for inspection of water to ensure purity before release to the environment. Oil skim on water shall be removed using commercially available absorbents which shall be incinerated.

Concentrations of petroleum in discharge water shall be less than 5 ppm.

77. Ice and snow contaminated with petroleum products shall be stored in storage pits until melted by mild weather. Commercial absorbents shall be used to collect the oil which shall be incinerated.

Contingency Planning for Spill Control

Contingency planning is the key to effective spill management. It is essential that the Company's plans are complete, understood and ready for immediate implementation. The following section is an outline for what constitutes an acceptable contingency plan.

A. A Statement of Purpose

78. Contingency plans shall be prepared within the following terms of reference:

    (a) To inventory and marshal trained manpower, equipment and information to provide as effective means as possible within the limits of presently available technology of dealing with any particular incidents which may arise.

    (b) To enable prompt action which will control as much as possible the overall effect on the environment and the local community interests.

    (c) To enable the Company to discharge its responsibilities, both legal and otherwise.

    (d) To establish appropriate lines of communication and liaison with public authorities and communities involved or affected.

B. The Scope of a Plan

79. The plan shall include spill emergency schemes on everything within the right-of-way and support facilities. It shall also take into account accidents or environmental extremes which could originate outside or spread beyond the right-of-way boundaries such as oil or chemical spills from other operations in the area, flooding, landslides and vandalism.

C. The Planning and Response Elements

80. This part of the plan shall explain how the contingency plan is organized, how it fits into other plans in the area and how the emergency response shall be co-ordinated. The petrochemical and hazardous materials spill contingency plan for a pipeline shall be designed with components similar to the following:

(a) Headquarters Spill Team, comprising a chairman, deputy chairman, environmental affairs advisor, legal advisor, and and public relations advisor. This team shall initiate, authorize and co-ordinate matters of policy, organization and technology, and will become directly involved only in very large or serious oil spills.

(b) Spread Spill Teams comprising heads of operating and service units located in the spread. An on-scene co-ordinator, logistics manager (transportation, communications and accomodation), equipment manager (clean up devices and materials), manpower manager (company employees and contractors), public information spokesman and office services manager will be appointed from this staff. These teams shall organize and approve contingency plans and equipment procurement for their spread; communicate and co-ordinate action of the on-scene co-ordinator (see 'd' below), and shall show awareness of spills occurring within the spread.

(c) Spread Spill Team Staff Groups composed of personnel from the operating and service units located in the spread. These groups shall prepare plans, specify equipment and man operating centres during responses to spills.

(d) On-Scene Co-ordinators, appointed from spread personnel by spread spill team. They shall assume responsibility for directing Company action in spills when directed by the spread spill team.

(e) Operating Units appointed from spread personnel by spread spill team. They shall handle spills within their own spread operations, have custody of spread of spread spill equipment, participate in local industry

co-operatives, train personnel and furnish manpower as requested by the on-scene co-ordinator.

(f) A Spill Reponse Centre shall be pre-designated as the operations co-ordinating centre to implement contingency plans for spill emergencies in each spread.

D. Company Policies and Responsibilities

81. A brief point form outline of senior management directives on policy matters, legal requirements and environmental responsibilities shall be included in the Contingency Plan.

E. Response Operations

82. Actions taken to respond to a spill incident can be divided into five overlapping phases. These are: discovery and notification; containment and counter-measures; clean up and disposal; restoration; and settling of damages, clean-up costs and fines.

Discovery and Notification:

Spill discovery could be the result of casual observation or by routine facility checks by the Company staff and contractors. Notification includes internal Company organization reporting and external government, affected public and possible news media alerting. The following steps shall be taken by the Company to ensure that spills are promptly discovered and appropriate notification is given:

(a) Personnel manning Company telephone and radio-telephone numbers normally available for service to the public shall be informed of whom to notify in the pipeline corporation if a leak or spill is spotted by a member of the public and reported to these numbers.

(b) A spill emergency telephone number shall be circulated to government agencies concerned with spills of hazardous substances from a pipeline project into the environment, (e.g. Ministry of Transport, Department of the Environment, Department of Indian and Northern Affairs) to enable them to contact the Company through

suitable channels if they receive reports of or observe spills from the pipeline installations.

(c) A documented system of regularly scheduled inspections of pipeline facilities shall be followed by the Company staff to check for actual and potential fuel leaks or spills at key areas along the pipeline and around associated facility property. Systems of automatic alarms for warning of tankfarm leaks or oil transfer operation spills should be considered.

(d) A spill notification and information system shall be instituted in the Company organization to inform appropriate senior staff and concerned government agencies and potentially affected industries and municipalities of a spill and keep them informed on containment and clean up activities. The severity of the spill will generally determine the notification pattern and extent.

Containment and Countermeasures:

This phase includes the deployment of booms, absorbents, vacuum pumps etc., necessary to contain or neutralize the spilled substance or protect property (water intakes, small craft harbours, bird sanctuaries etc.) from the pollution. It would also include any measures necessary to stop more pollutant from spilling. (See recommendations on Clean up Equipment Selection and Deployment). The following steps shall be taken by the Company to ensure that proper preparations are made in this area:

(a) The Company shall be a member of the National Emergency Equipment Locator System (NEELS), a computerized inventory bank of clean up equipment available in Canada.

(b) Trained personnel shall be available at key installations along the route to handle containment and clean up equipment. (See recommendations on Personnel Training for Spill Control). Periodic "mock exercises" shall be held to keep clean up personnel up-to-date, and equipment in working order. The exercises shall include the following general steps that shall be undertaken when a spill occurs:

(i) The product flow shall be stopped by shutting off pumps, closing valves, or taking other steps as required.

(ii) People in the immediate area shall be warned and evacuated if necessary.

(iii) If the product is highly flammable, ignition sources such as motors in cars or trucks, electrical circuits, ordinary light bulbs and open flames (including pilot lights) shall be shut off.

(vi) The oil spill shall be contained by blocking off drains, culverts and ditches with earth, sand, booms or natural and commercial absorbents etc.

(v) Notification of the spill to the appropriate Company staff and government officials shall be given.

(vi) Assistance of other companies, contractors or government personnel shall be requested if necessary.

(vii) Spilled product recovery, clean up and the restoration of facilities and environment shall be undertaken.

(c) During construction, containment and clean up, equipment shall be stockpiled at high spill risk installations and areas that are environmentally or socially sensitive to fuel or chemical spills.

(d) Special methods for cleaning up oil from ice-infested waters and oil under ice which might result from present experiments being carried out in Beaufort Sea Oil contaminant and pick up research programs shall be incorporated into the pipeline action plans when they are developed.

(e) Dispersing materials shall only be used in Mackenzie Valley-Beaufort Sea pollution containment or clean up operations, within the restrictive guidelines published by Environment Canada for the controlled use of these materials.

(f) The Company shall formalize cooperative spill working arrangements with the other petroleum and industrial operators along the pipeline route. Equipment purchases by these organizations could then be further coordinated and clean up staffs augmented for maximum efficiency.

Clean Up and Disposal:

This work involves the actions necessary to remove a pollutant from the water and related onshore areas using absorbents, skimmers and earthmoving machinery to physically pick up contaminated snow, ice and beach materials (See Clean up Equipment Selection and Deployment).

(a) Pollutants and contaminated materials shall be disposed in predesignated locations where they will not re-contaminate the environment.

(b) In an area having the fluctuating river and marine water level environments along the pipeline routes, this work must be done on a 24 hours basis to prevent high water levels or heavy precipitation moving spilled material from polluted beaches, riverbanks, ditches and ice surfaces to areas which were not previously contaminated.

Restoration:

This phase covers soil or shoreline material restoration, cleaning of private property such as piers and boats, and restoring to the satisfaction of the appropriate government agency as much as necessary of the living environment such as attempting rehabilitation of oiled birds or restocking of aquatic resources. The following steps shall be taken by the company for this phase:

(a) Soil restoration shall be done with advice from recognized contaminated soil restoration experts, who could set up a program specific to the contamination problem at the site.

(b) Cleaning of docks, boats and other private property shall be done on a high priority basis, or alternatively on-the-spot cash settlements shall be made to enable the

affected parties to have their property cleaned by a private company.

(c) Recreational and settlement beach restoration shall be done according to agreements reached with local territorial and settlement representatives.

(d) Bird and aquatic fauna rehabilitations shall be done according to agreements with Environment Canada officials and advice from the Canadian Wildlife Service.

Payment of Damages, Clean Up Cost and Fines:

This phase generally takes place last, but the information and actions required in it must be recorded in detail from the start of the incident.

The Company shall carry out the following steps:

(a) All Company supervisory personnel involved in the incident shall keep thorough detailed notes of their activities and decisions during the incident.

(b) Company legal staff shall be assigned to work with government agencies, clean up contractors and small claims from boat owners, fishermen and others during and after the incident.

(c) Small straight-forward claims from fishermen, private citizens and small businesses shall be settled quickly.

F. Overall Coordinating Instructions

83. This section of the Contigency Plan shall contain all the information required by operational personnel, to fully understand how an incident would be managed.

The Company shall ensure the following conditions are followed:

(a) Since communication among clean up forces is extremely important electronic portable communications among the operational personnel shall be of an excellent standard.

(b) Spill clean up progress briefings shall take place daily at the operations centre(s) during the period action is required on an emergency basis. All clean up staff supervisors, spill team members, advisors, etc., should be present.

(c) Detailed minutes of these meetings shall be kept.

(d) Liaison personnel of senior management, press and government agencies, shall attend the daily briefings.

(e) Press conferences shall be held at least once a day with the On-Scene Coordinator and any necessary technical advisers in attendance. A Company public relations staff member shall be available to the press at any time and arrange tours and telephone facilities for them.

G. Appendices to a Plan

84. Non-operational sections of the action plan shall contain information on word definitions, who has copies of the plan, plan up-dating procedures, communications, legal authorities, financial procedures and a list of non-Company plans for the pipeline route areas.

The Company shall ensure the following steps are taken:

(a) The plan shall be distributed to all appropriate Company headquarters and field staff, and government agencies operationally concerned or having jurisdiction along the route.

(b) The plan shall be up-dated and operationally tested by field exercises at least once a year on a scheduled and documented basis. Plans of these exercises shall be submitted to the relevant government agency for review one month in advance of the exercise taking place.

(c) Portable radio and telephone communications shall be reviewed and use procedures outlined.

(d) Legislation applicable to a spill incident along the route shall be summarized.

(e) The non-Company action plans along the route shall be listed.

Personnel Training for Spill Control

A. Organization of Spill Team Personnel

85. Key personnel in spread spill teams should attend training schools and relevant conferences on petrochemical spill clean up. (Such schools are regularly scheduled in Edmonton [PITS], San Francisco [Clean Bay Inc.], at Texas A and M University and in Warren Springs, England.)

86. The categories of work to be done on each spill team shall be decided upon and documented as outlined in "Contingency Planning for Spill Control".

87. On small spills, one man can handle multiple jobs, but on a big spill, it takes a full slate of people in many categories. An organization chart shall be prepared, which describes the many jobs to be done in cleaning up spilled oil on land and waterbodies along the route.

88. A task analysis and a detailed work description for each job shall be prepared.

89. Personnel shall be selected to form a spill team for each spread. People should be selected whose industry jobs most nearly match the description of the job they will perform on the response team.

90. A performance objective shall be written for a series of seminars designed to bring together all persons assigned to a particular job on the spill team.

B. Spill Team Training Program

91. An actual training program for a spill team shall require the following:

    (a) a printed organization chart of the response team showing all job titles and who relates to whom;

    (b) a formal and detailed job description of each job;

(c) a series of 10-15 action objectives for each man assigned to each job to reach during his training session and after the training session on his own;

(d) a series of seminars for each job where all objectives are met and accomplished by every participant; each participant should use all required training tools and techniques, including visual aid equipment, actual clean up equipment, radios, etc.; and

(e) a call out and practice session where all members of the team practise their skills in the field.

92. Key hazardous material handling and spill control personnel shall be trained at least six months in advance of the start of construction.

Clean Up Equipment Selection and Deployment

A. Equipment

93. A list of spill response equipment for a pipeline shall include devices and materials in the following categories:

    (a) Containment Booms: The booms shall be of the appropriate size and types for use in the Arctic Ocean, lakes, harbours, streams and rivers. These can be made of polyethelene coated nylon fabric, absorbents, or belting (for permanent dock booming).

    (b) Pick-up and Dispersion: Skimmers, vaccuum trucks and tanks, slurp pumps, absorbents (natural and patent commercial), manual pick-up tools, dispersant spray units and dispersants shall be stockpiled.

    (c) Necessary Miscellaneous Equipment: Other equipment such as the following shall be readily available:

rope	port-a-tanks
trash pumps	hand tools
explosimeter	hard hats
respirator	rubber boots
chain saw	rubber jackets & pants
bulhorns	gloves
fire extinguishers	goggles
walkie-talkies	lighting generators
gasoline cans	anchors
flashlights	chains
shovels	shackles
rakes	empty drums
ensilage forks	plastic bags
stakes	first aid kits
chicken wire	

    (d) Each On-scene Coordinator shall have a spill equipment inventory system available for immediate reference at any time.

    (e) Any list of available equipment shall include means of transportation for equipment, materials and manpower by air, land and water. It shall also include locations of

heavy equipment such as bulldozers, power shovels and other earth-moving machinery to build dykes, fill ditches, prepare dams, bury the spilled material or whatever other operations are deemed necessary.

B. Equipment Deployment Schemes

Comment: Spills of petrochemicals from a gas pipeline project could originate from fuel and chemical barge or tanker groundings and collisions, product transfer operations between transportation modes and storage farms and from storage tanks themselves. In the case of groundings, a simultaneous requirement of lightening the stricken vessel could be necessary to facilitate salvage operations and avert further spillage.

The successful clean up of a spill relies on the combination of one or more techniques of confinement, removal, and disposal in an integrated operation which is appropriate for that unique situation. The range of circumstances for spills is so large that it is nct possible to give hard and fast recommendations on the optium selection and combination of methods for each individual situation. However, general approaches can be outlined.

94. Complete engineering plans for pumping, piping, valving and compartmentalization of tankfarms and marine transportation vessels shall be available at appropriate spread spill operations centres for easy reference in an emergency.

95. For each chemical and petroleum product used during construction and operation of a gas line, a complete assessment of the following characteristics shall be made:

    (a) toxicity;

    (b) solubility;

    (c) biodegradability;

    (d) volatility;

    (e) density;

    (f) surface activity; and

(g) flammability.

These parameters shall be summarized in chart form, stored at appropriate spread spill operations centres for easy reference in an emergency. Some chemicals may be found to present an unacceptably high risk to the environment if they are shipped in bulk, in which case they could be substituted or moved in specially equipped transport.

96. The selection of equipment types and storage locations to be used in the event of an cil spill shall be developed:

(a) through predetermining potential spill locations;

(b) by analysis of conditions at each site;

(c) by preparing a response (equipment deployment) plan for each area; and

(d) by training manpower and conducting mock exercises to practise carrying out each plan.

Land Operations:

97. Every effort shall be made to contain any spill on land before it gets into any waterbody. Consideration should be given to fabricating and installing spill barriers in surface runoff ditches and depressions likely to catch oil or chemicals around some facilities.

98. A spill shall be removed quickly from drainage ditches or a tankfarm containment dyke area by using pumping systems with skimming heads, commercial or natural absorbents, physical removal of contaminated ground or burning under permit.

99. In winter, snow and ice contaminated by a spill shall be moved to predesignated storage sites. Oil and chemicals released in spring melts shall then be treated in runoff control systems (See recommendations on Spill Prevention from Storage and Transportation Facilities).

River and Lake Operations:

100. In the event containment action fails on land, a stream, lake or river channel operation is necessary.

(a) In ice-free conditions:

(i) Booms shall be deployed at critical points along the shoreline to protect important waterfowl and fish resource areas and key water intakes, small boat wharfs and fishery areas. Bird scaring devices shall be considered in some areas to keep waterfowl away from a slick.

(ii) Booms shall be deployed in river channels at predetermined sites to attempt to contain the spill where the current is not too strong, or to deflect the oil into predesignated collecting areas along the shoreline if the river flow velocity is high. The Company shall make assessments downstream of all fuel and chemical storage sites and marine vessel transport routes and product transfer points (e.g. tankfarms, wharf sites, offshore bouys etc.).

(iii) Booms shall be deployed anywhere in larger waterbodies where oil can be trapped or corralled. Skimmers shall be used to collect as much material as possible which is diverted towards them with booms.

(b) In ice-infested waters:

(i) If solid ice cover is present, a spill shall be contained on the ice surface.

(ii) If broken ice conditions are encountered, or a spill is beneath ice, containment will probably not be possible. In these cases, movement of the material shall be monitored visually by aircraft and by a snow, ice and water sampling program.

Beaufort Sea Operations:

101. In the event containment action fails on land and in a watercourse channel, a Beaufort Sea operation could be necessary.

(a) In ice-free conditions:

(i) Booms shall be deployed in the Beaufort Sea to protect key bird, marine mammal, fisheries and harbour areas. Bird scarer devices shall be considered to keep waterfowl away from slicks.

(ii) Booms, skimmers and absorbents shall be deployed, weather permitting, to attempt to pick up floating spilled material.

(b) In ice-infested waters:

(i) Steps outlined above for spills in ice infested streams and rivers should be attempted.

SOURCES OF INFORMATION

The above recommendations were adapted directly from the report "Draft Terms and Conditions for Petrochemical Spill Prevention and Control (September 30, 1976)" prepared by Canguard Consulting Limited of Vancouver for the Inquiry Appraisal Team. Canguard notes that the following Legislation was considered in developing the recommendations:

Canada Shipping Act

1. Collision regulations
2. Fire Detection and Extinguishing Equipment Regulations
3. Garbage Pollution Prevention Regulations
4. Home Trade, Inland and Minor Waters Voyages Regulations
5. Hull Construction Regulations

6. Load Line Regulations (Inland)
7. Load Line Regulations (Sea)
8. Navigating Appliances Regulations
9. Oil Pollution Prevention Regulations
10. Raft and Barge Navigation Regulations
11. Safe Manning Regulations
12. Safe Working Practices Regulations
13. Steamship Machinery Construction Regulations

Arctic Waters Pollution Prevention Act

1. Arctic Shipping Pollution Prevention Regulations
2. Shipping Safety Control Zones Order

Others

1. Code of Navigating Practices and Procedures
2. Stability Standards, Particularly "Stab 3" and Stab 7"
3. Structural Fire Protection Standards, Parts I and II
4. Dangerous Goods Shipping Regulations

Canguard notes that the following environmental legislation was taken into account:

Federal Acts

1. Department of Indian Affairs and Northern Development administered Acts and Regulations:

   (a) Northern Inland Waters Act

(b) Arctic Waters Pollution Prevention Act

(c) Territorial Lands Act

(d) The Oil and Gas Production and Conservation Act

2. Department of the Environment administered Acts and Regulations

    (a) The Fisheries Act

    (b) Migratory Birds Convention Act

    (c) Canada Water Act

    (d) Clean Air Act

    (e) Environmental Contaminants Act

    (f) Ocean Dumping Act

<u>Territorial Ordinances</u>

(a) Environmental Protection Ordinances (NWT)

(b) Gas Handling Ordinance

(c) Public Health Ordinance

(d) The Territorial Petroleum Products Ordinance (Part 2)

The Canguard report was cognizant of and supplemented by reference to the following:

1. Transcripts, Exhibits, Basic Documents

COPE Barry, T.W.; Grainger, E.H.; Sergeant, D.F.; Smith, T.G.; Stein, J.N.; Percy, J.A. (121: 18360-487); Logan, W.J.; Pettigrew, R.K.; Snow, N. (125: 19084-141; 126: 19143-299); Nicol, C.W. (139: 21204-26; 140: 21277-99)

Exhibit 666: CAGSL. 1976. The control of hazardous substances during the Arctic gas project.

668: CAGSL. 1976. Arctic oil spills and toxic materials contingency plan.

2. Reports

Canada. DOE. Environment Protection Service
Code of good practice for management of hazardous and toxic wastes at federal establishment.

FIRE PREVENTION AND CONTROL

GENERAL RECOMMENDATION

The Company shall submit to the Agency plans for the prevention and control of fire during the construction and operation of the pipeline. These plans shall be developed in collaboration with the Yukon Forestry Service and the Northwest Lands and Forest Service and shall include information on employee education and training, fire reporting procedures, equipment type and placement, summer and winter fire prevention measures, equipment and employee mobilization, rehabilitation procedures to be implemented following a fire, and any other information the two Services may require.

DISCUSSION

Many fires are started as a result of human activity. There is concern that the increased labour force concomitant with pipeline construction will not increase the frequency of fire. During winter the main danger arises from vegetation clearing and burning. Where timber is disposed of by burning on the ground a smoulder fire may be started in the organic mat and remain hidden until it suddenly flares the following spring.

The dangers from summer activities are much greater, but do not seem to have received sufficient emphasis by the Applicants. The level of summer activity is quite high; surveying, support facility installation, the stockpiling of material, compressor station construction, some vegetation and right-of-way clearing will take place. All of these activities could occur at a time when the risk of fire is very high and it could prove necessary during periods of such high risk to exclude labour from an area and suspend summer construction activity. This greatly increased risk from summer construction activities over winter construction activities must be recognized in any formulation of plans for the prevention and control of fire.

The danger associated with fires in or near compressor stations and metering stations appears underestimated. There is a lack of emphasis on the development of control procedures for such occurrences which is of concern because hasty and ill-provised procedures such as bulldozing fire-guards can sometimes be environmentally damaging especially in permafrost areas.

A recognition of the dangers and the development of plans to meet these dangers is warranted.

There is also a concern that the dangers of fires in permafrost areas have not been sufficiently stressed, especially with regard to restoration measures. Fire can seriously weaken the insulating effect of the vegetation and its associated organic mat, with the result that terrain instability could result and the integrity of the pipeline could be threatened. These dangers must be considered fully in any development of contigency measures following fires.

RECOMMENDATION: THE COMPANY

See general recommendation above.

SOURCES OF INFORMATION

1. <u>Transcripts, Exhibits, Basic Documents</u>

   PAAG Report

PROJECT REGULATION

PROJECT REGULATION AND CONTROL: THE GOVERNMENT

GENERAL RECOMMENDATIONS

The government should establish a single Agency to regulate and control all the technical, environmental and social aspects of the pipeline project. In addition, the government should modify the prevailing distribution of control over resources in the North by withdrawing certain lands from development and by providing for the kind of territorial self-determination and entrenchment of native land rights which will assure the people of the North a meaningful voice in changes that affect them and their region.

It must be recognized that these submissions have been prepared without sufficient time to consider much evidence relevant to this subject which was heard during the final week of the Inquiry. It is therefore necessary to reserve the right to add to these submissions after considering that material.

DISCUSSION

The regulation and control of a pipeline project of this magnitude will be an immensely challenging task, going well beyond the technical aspects of traditional engineering and environmental enforcement. The scope of this emerging social and political context will inevitably result in fundamental and perhaps irreversible changes in northern regional evolution. The task requires the utmost care and responsiveness if the mistakes of the past are to be avoided.

The pipeline project ranks as one of the largest civil works ever undertaken by private enterprise. The Inquiry has been told that it could shape the development of the Mackenzie Valley and its people in a way similar to the CPR in the opening of the west (R. Page, vols. 146, 147). The potential for great industrial progress is fraught with dangers of permanent social and environmental harm. Clearly, the impact of the pipeline project will be governed as much by the actions of government as by the initiatives of the pipeline company and the hydrocarbon industry.

Regulation of very large ventures is extremely difficult. Huge financial commitments, national and international interests, political ramifications and institutionalized regulatory approaches often jeopardize compliance with and enforcement of even the very best stipulations. This pipeline project will encounter such problems, aggravated by the unique technical aspects of the work, the remoteness of work locations, the severe environmental constraints and the nature of the socio-economic milieu of the North.

There is compelling evidence before the Inquiry that a new approach to regulation and control is needed for this project. Witnesses from Alaska have testified to the inadequacies of the regulation of the Alyeska project. Witnesses in the communities and at the formal hearings have cited inadequacies in the present approach to control of development activities. Native organizations and individual native people have argued vehemently that controlled development can not take place until the issues of land claims and regional self-determination are settled. The traditional regulatory approach has, time and again, failed to achieve the essential environmental and socio-economic results. A new approach therefore, seems a fundamental necessity.

The first characteristic of such a new approach should be the use of a single regulatory Agency. And while this "control by a regulatory body" approach will have a key role to play, it must be only one part of the process if effective control of impact is to be achieved. Two other components are necessary. First, the social, political and economic issue of land claims must be resolved. Second, environmentally important lands must be protected from development by land withdrawals. These aspects of control, land claims and land withdrawal are dealt with elsewhere in these submissions. The main thrust of this section is to deal with the issue of control by regulation, and to affirm the principle that a regulatory mechanism must be integrated with and responsive to the concerns of interested parties.

The regulatory Agency established by government must combine the multitude of "government" and "government agency" mandates and responsibilities into a single unit capable of effectively dealing with a gigantic project under the most critical engineering, environmental, social and time constraints. The Agency must have real and publicly perceived credibility in all aspects of project control, and particularly in the environmental and social areas. This means that various environmental interest groups, the native people and other affected interest groups must be convinced that their interests will be protected in every possible way, and must have an effective and expeditious mechanism by which they can interfere if their interests are being ignored. No existing government department of agency has at present the necessary capacity or mandate, or the necessary responsiveness. The need for inovative approaches is apparent.

RECOMMENDATIONS

<u>Government Organization</u>

1. The government should proceed as quickly as possible to establish a single agency approach for regulation of the construction of the pipeline project, the gas plants

and all related activities by bringing together under one management the multitude of jurisdictions and responsibilities spread throughout federal and territorial departments and agencies. For this project, the Agency should include the traditional construction regulation and control roles of the NEB.

Comment: The immensity of the project, its huge cost, its multigovernmental/departmental and its national and international ramifications make it essential that the government have a "one window" approach to the Company, the other parts of government and the public. There must be a single regulatory Agency.

That Agency must have authority over pipeline work, gas plant work and all related activities. Only in this way can the regulation of these matters be made coherent and consistent. It is of course recognized that the construction of the gas plants and gathering systems requires distinct and often different controls than does the pipeline itself. Nonetheless, these projects, integrally connected as they are, must be controlled under one roof, and must be responsive in the same immediate way to the interests of affected third parties. For regulation to be effective and in the public interest, both the Company and the public must look in at the same "window".

The Agency should administer all relevant Acts, Regulations, Ordinances, orders-in-council, accords, executive agreements, codes and standards, that apply to the pipeline project, the gas plants and related facilities. This includes of course all terms and conditions that may be attached to the granting of a right-of-way.

2. The single Agency should incorporate the environmental, social and local economic controls on the project on an equal footing with engineering controls. There should not be a dominant "decision" group and a subserviant "advisory" group. There should be social, economic, environmental and engineering considerations brought to bear at each stage of the Agency's control activities. This requires that all be housed at the same head office. It would erode the even handed control sought if, for example, those responsible for social controls were housed in a separate building, or worse, a separate city from the rest of the Agency.

3. To adequately discharge its mandate the Agency must, at a minimum, engage in the following activities:

   a) Preliminary Design Review - this control function must be conducted at a sufficiently early stage that changes required by the Agency can be included by the companies affected in their contracts for materials and supplies. Such changes must of course be included in the applicable final designs. Further-

more, this design review stage is the appropriate and most effective point at which third party social and environmental interests should be brought to bear on the design, and at which changes prompted by these interests should be made. It is critical that the parties involved be prepared to participate in this design review process at this stage, and that they have access to sufficient funds to enable them to do so to their satisfaction. Finally, it is equally important that the participation of interested parties be continuous throughout all of the phases (b)-(d) outlined below, to ensure that the spirit as well as the letter of the preliminary design review conditions are met, and that any changes in design are consistent with the principles established in the granting of a right-of-way and confirmed during preliminary design review.

(b) Final Design Review - this control function follows the submission by the company of its final design. The changes which are required by the Agency lead to final design modifications.

(c) Notice to construct - this control function consists of an on-site permission to proceed once the Agency enforcement officer (that is, the Agency's representative in the field) is satisfied that final design specifications have been satisfied at the work site.

(d) Surveillance of construction activities - this is the traditional control function of inspection to ensure compliance with applicable regulations and stipulations. The enforcement techniques available to the Agency in discharging this task are discussed elsewhere in this submission.

4. The Agency must provide for an appeal procedure from any Agency decision yielded by any of the four control procedures set out in paragraph 3 above. The final forum for appeal of such decisions shall be the head of the Agency.

5. The government should establish a monitoring program, with direct participation by all of the interested parties, to start before pipeline construction begins, continuing during pipeline operation and following abandonment. This monitoring group would conduct a continuing impact assessment of all regulated activities. The monitoring group would report regularly to the regulating Agency, recommending such modifications of the applicable regulations as are shown necessary by the continuing impact assessment. Such recommendations must be followed by the regulating Agency. Only in this way can regulations inadequate to protect the social or natural environment be identified and altered.

6. The prime responsibility of the Agency will be the regulation of the construction activities concerned. However certain of the regulations and stipulations to be administered by the Agency will continue to have effect after construction is completed. For example there may be regulations relating to the operation of the controlled facilities. There may also be regulations requiring certain Company conduct in such things as training that extends beyond the time frame envisaged for construction. In addition the Inquiry has been told that "looping" of the first pipeline is a likely prospect. In these circumstances, it is recommended that the Government set up the single Agency without a predetermined life span so that the utility of the Agency's continuing operation can be reassessed at the conclusion of the construction of the subject facilities, and in the light of whatever other mechanisms may have been developed in the interim.

7. The government should not appoint an independent public auditor group. The Inquiry has heard much evidence about groups of this kind particularly as they have functioned in the Alaskan experience. It is submitted that such groups have proven to be largely ineffective in being able to monitor large construction projects on a regular basis and even more ineffective in effecting any changes in construction activities. The expediture of funds on such an organization therefore seems unjustified, and the fiction that the public interest is being protected by the existence of such a group seems potentially harmful.

8. It is recommended that the costs of the Agency be assessed against the projects being regulated. This is consistent with the provisions of the "1972 Pipeline Guidelines".

9. It is recommended that the agency be so structured as to provide for active third party involvement by third parties whose interests are affected by the regulated projects. These groups include environmental groups, northern native groups, and communities in the greater impact region of the proposed projects. This active participation should be effected in the following ways:

   a) The government should invite environmental groups with a declared interest in the North to appoint a representative of their interests to sit on the senior Agency committees charged with the control functions set out in paragraph 3 above. This representative would be given the same access to information, the access to research capabilities and the same decision making power as any other member of the committee.

The government should make the same invitation to each of the territorial native groups in the N.W.T. and to the communities in the greater impact region. These representatives would of course be fully remunerated for their services and would be appointed to terms of sufficient length to ensure their effectiveness, at a minimum two years.

b) The special status of native northerners as (at the very least, in the absence of a land claims settlement) unspecified landowners through whose property a right-of-way is being granted should be recognized in the structure and responsibility of the Agency, either by participation on a board of directors to which the head of the Agency is answerable or by some comparable scheme.

c) The necessity of facilitating public interest intervention in the operation of the Agency must be recognized as an integral part of a responsible regulatory system. This kind of intervention is quite separate from the participation of interested parties in the functions of the Agency referred to in (a) . It will be effective only if it is informed by a continuous presence sufficient to monitor the operations of the Agency. The funding of these intervenors must be separate from the funding referred to in (a), and should be shared by government and the public interest intervenors. A possible mechanism to achieve public interest intervention would give public interest groups such as those identified in (a) above the right to monitor Agency decision making and make submissions to the Agency decision makers in advance of decision.

Code

10. The government should immediately prepare a Code of performance, conduct and methodology for the pipeline, gas plants and related projects based on the recommendations continued in the text of this submission. It should detail all requirements to be imposed on the Company including those requirements under existing laws and regulations. The Code should be made legally binding on the Company and all its contractors.

Comment

An adequate Code will be essential very early in the project before the Company makes its basic decision that will govern future operations and procedures. The Code will be the government's basic document that will parallel the Company's Design Manual and Design Change Manual. The Code must be prepared in sufficient time for the Company to use it in preparing its preliminary plans.

11. The Code should be prepared as a comprehensive documentation of regulations and practices to guide the Company but it shall in no way limit the jurisdiction or authority of the Agency to implement additional conditions as it sees fit during the course of the design review and surveillance.

12. The Code should be supplemented by a Field Activity Atlas prepared by the Agency. The Field Activity Atlas should be a graphic, easily understood, project-specific field guide for field personnel, illustrating site-specific engineering, environmental and social constraints or considerations.

Comment:

The Atlas would be used on-site to advise field personnel of the local features that must be considered in the day to day construction and construction related activities. An extensive written document is too cumbersome while a graphic display would be more easily understood and more widely used.

13. Relevant elements of the code should be applied uniformly by the government in all other government department and crown agency operations and jurisdictions in the Yukon, Mackenzie District of the N.W.T., and the Beaufort Sea for the duration of pipeline construction.

Comment:

The uniform application of those elements of the Code that are of general application to all activities throughout the area will assure that physical and living environments are sustained in the considered manner. For example, it would be somewhat pointless to impose one set of strict conditions for a pipeline river crossing if nearby another unrelated operation were allowed to proceed under a set of less rigid conditions. There should not be "double standard" performance criteria.

14. The Agency should prohibit all on site activities related to the Company's proposed works until the necessary reviews, approvals and authorizations are issued. No such documents should be issued by the Agency until it is satisfied that all stipulations have been and will be complied with by the Company.

SOURCES OF INFORMATION

Organization

1. Transcripts, Exhibits, Basic Documents

CAGPL	Genest, P. (68:10212); Horte, V. (43:5705-14, 45:5932-37, 5946-48; 49:6599-608); Walker, C.E. (105:16016-20)
FH	Blair, S.R. (58:8196-97; 59:8304-05); Bouckhout, C.W. (100:15191-96)
CARC	Lent, P.C. (106:16251-59; 111:16943-54); Steinberger, L.W. (105:16020-24); Stein, J.N. (105:16016-20); Weedon, R. (75:11074-75)
EPB	Craik, D.W. (48:6315-27, 6354-72; 107:16230, 16319-21, 16386); Templeton, C.H. (46:6033, 6058; 47:6275-80; 48:6344-46, 6423-50; 68:10193-205, 10209-14, 10221-23; 107:16317-27, 16377-80)
IB/MA NWT	Page, R. (146:22323-50; 147 :22350-74)
Comm.C.	Mossop. D.H. (138:21020-21; 139:2113-34); Norton, D.W. (138:20941-83); Simmons, N.M. (138:20989-90; 139:21113-34, 21169-70); Stephen, W.J. (138:20997-1002; 139:21161-62, 21167-69)
Exhibit	595: Qualifications and Evidence of R. Page.
	863: Skinnarland, E. 1976. Brief on authorities and procedures for implementation of stipulations forming part of a right-of-way permit for a Mackenzie Valley gas pipeline (CARC).
	866: Thompson, A.R. 1976. Evidence on implementation (CARC).
	881: Beakhu st, G.J. 1976. Problems of regulating industrial activity in the Canadian north (COPE).
	882: Zemansky, G.M. 1976. Environmental non-compliance and the public interest (COPE).

2. Reports

Canada. DOE Environmental Protection Service.
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Canada, DINA. Working Group Project Office.
1976a Working group or government operations during northern pipeline construction; Summary report.

1976b Working group on government. Operations during northern pipeline construction; Discussion paper on option No. II (Authority); Draft No. 3.

Independant Auditor Group

1. Transcripts, Exhibits, Basic Documents

EPB Craik, D.W. (107:16385); McTaggart-Cowan, I. (108:16576-87); Templeton, C.H. (48:6437; 68:10193-202; 107:16378-88; 108:16477-78; Wylimovsky, N.J. (48:6327-29, 6373-74; 108:16575-82; 109:16590-96)

Comm.C. Sprague, J.B. (135:20586; 136:20645-46, 20664-66)

2. Reports

Environment Protection Board

1974 Towards an environmental code; Vol I, pp. 53,75.

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Transcripts, Exhibits, Basic Documents

CAGPL Gunn, W.H. (97:14803-05); Hemstock, R.A. (82:12252); McCart, P.J. (97:14806-10)

EPB Adam, K. (48:6407-10); Bliss, L.C. (48:6416, 6420); Craik, D.W. (48:6363-66, 6410-13); Mctaggart-Cowan,

I. (48:6395-400, 6403-06, 6420); Templeton, C.H. (47:6280-98; 48:6375-79, 6426, 6439-40; 68:10223-33; 108:16480; 109:16701-08, 16710-14); Wylimovsky, N.J. (48:6406-07, 6413)

Comm.C. Norton, D.W. (138:20952-55)

Design Review

1. Transcripts, Exhibits, Basic Documents

Berger (65:9506)

CAGPL Dau, P.H. (38:4870-77)

EPB Craik, D.W. (48:6361-63); Templeton, C.H. (48:6430-31; 108:16478-79)

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n.d. Federal and state stipulations governing the trans Alaska pipeline system.

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1976 Draft environmental code for the development of the proposed Mackenzie Valley gas pipeline; prepared for DOE, EPS.

Consultation

Transcripts, Exhibits, Basic Documents

CAGPL	Horte, V. (50:6623-32)
EPB	Templeton, C.H. (68:10196)
COPE	Allison, L.; Cournoyea, N.J.; Noble, G.P.; Usher, P.J. (140-141)
Private	References to past consultation process also appears throughout the community hearing transcripts. The list of such references is extensive and is not included here.

PROJECT REGULATION: THE COMPANY

GENERAL RECOMMENDATION

The Company shall design, construct, operate and otherwise manage all aspects of the pipeline project in a comprehensive manner so that there is compliance with all government and Agency stipulations relating to the project.

DISCUSSION

The Company must assume the responsibility of ensuring that all employees and contractors engaged on the pipeline project perform in a manner consistent with the various stipulations of government and the Agency as they are advanced in the various formal approvals and as specified in the field by inspectors. This will be a major task for the Company. It will require the use of legally binding contracts, exhaustive inspection, rigid quality control and swift and decisive punative action by the Company for infractions.

The success of the project from the engineering, environmental and social points of view rests primarily with the Company. The Company can expect no better performance from its employees and contractors that it demands of itself. Therefore, the Company must continually demonstrate that it can and will regulate the project to achieve the required technical quality, environmental integrity and social probity.

Throughout the hearings the Applicants have repeated assurances that they can and will engineer, construct and regulate the project in a manner that will produce a pipeline which is environmentally and socially acceptable. However this question remains: Can the Company, no matter how sincere, carry out its assurances under the obvious scheduling and financial pressures and the necessary technical, environmental and social constraints? G.M. Zemansky highlighted the dilemma by quoting from a memorandum written by a monitor on construction of the pipeline project in Alsaka:

> "If Alyeska is sincere ... then the worst fears of environmental groups are verified: the present state-of-the-art, both engineering art and management art, is not advanced enough to build an environmentally acceptable pipeline in the Arctic" (Exhibit 882, p.18).

The challenge to the Company building an arctic pipeline in Canada is clear. To meet the challenge, and achieve a project that is environmentally and socially acceptable, the Company should observe certain organizational tenets.

RECOMMENDATIONS: THE COMPANY

Organization - General

1. Within 20 days of receiving the necessary project approvals from government the Company shall provide the Agency with a documented organization chart of the Company as it will be structured for construction purposes and for operating purposes.

Comment: The organization chart should show the Company hierarchy of office and field positions, the position title and the name of the individual who will fill the particular position. The documentation shall provide details on the duties and responsibilities assigned to each position and shall emphasize the interaction that each position has with: (a) the government project control mechanism both at head office and at field levels, (b) outside consultants and, (c) contractors and subcontractors. Also, the chart and documentation should highlight all permit, reporting relationships and authority for:

(a) environmental matters (of various types);

(c) implementation of employment agreements;

(d) preparation and implementation of contingency plans; and

(e) other items as requested by the Agency.

2. Within 20 days of receiving the right-of-way permit and or the Certificate of Convenience and Necessity from government Agency the Company shall submit to the government a fully documented organization chart for a typical construction spread during all of its various stages of work.

Comment: The document(s) should indicate the Company contractor and consultant positions that will be filled, their responsibilities and reporting functions, the interaction points with Agency representatives and the level of on-the-spot decision making powers relative to changing the construction routine, stopping of particular activities associated directly or indirectly with construction, etc.

3. Each application submitted to the Agency by the Company shall include activity schedule and personnel organization chart (see also "Project Regulation: The Government").

Comment: The organization chart should include all the Company's contractors' and consultants' key personnel on site with their names, positions, specific responsibilities and field authority.

4. The Company shall provide the Agency with complete updates of its organization charts and the related documentation (see 1 and 2 above) within 2 weeks of any changes and/or additions.

Contracts and Contractors

5. The Company shall, in all its contracts and subcontracts relating to supply, construction, operation, maintenance, surveillance, monitoring or other activity associated with the pipeline project legally bind all organizations or individuals directly or indirectly in its employ to the conditions imposed on the Company by the Government and the Agency.

6. Since all permits and approvals will be issued to the Company, it shall be responsible for all work and activities of its contractors and subcontractors and shall inspect all works done to assure that the work is done in the prescribed manner according to the stipulations of the Agency.

Design Manuals

7. The Company shall provide for Agency approval prior to final design, a comprehensive Design Manual to be used by the Company in arriving at its final mile by mile design. Such a manual shall be a designer's guide to all aspects of layout,

construction and operation of the pipeline and its related works.

8. The Company shall provide, for Agency approval, after commencement of final design but prior to field construction activity on any part of the project, a complete Design Change Manual which will be used in the field by the company personnel and inspectors charged with the responsibility of seeing that designs are properly implemented.

Comment: The Design Manual and Design Change Manual which both Applicants before the Inquiry have suggested are in preparation or will be prepared to guide their own design staff will, when approved by the Agency, become a basic reference document for those charged with design approvals. Therefore, both manuals must be made available to the Agency for thorough evaluation well in advance of final design submissions.

9. All design changes made subsequent to design approval shall be reported to the Agency within one week of the change being made. All changes to approved drawings or practices shall be supported by citing the field condition and by reference to relevant sections of the Design Manual or Design Change Manual or relevant instructions by the Agency field inspection representatives.

Quality Control

10. The Company shall designate in its own organization a distinct and separate group at both the field and head office levels, to be responsible for quality control of all phases of construction by ensuring that the approved designs, procedures and terms and conditions are implemented in the manner intended.

11. The Company shall have its own full time Quality Control Inspectors in the field.

Comment: Quality Control Inspectors should be assigned to appropriate locations on activities as specified by the Company or the Agency. For example Quality Control Inspectors should be assigned:

(a) on all active compressor station construction sites;

(b) on all active pipeline spreads where there is any excavation, laying of pipe and/or backfilling;

(c) at all places where there is pipe welding or X-raying taking place;

(d) at all active river crossing construction sites;

(e) at all pipe hydrostatic test sites during fill up, during the test and during disposal or transfer of the test liquid;

(f) at all sites where fuel, methanol or other hazardous or toxic substances are being transferred in bulk to or from storage areas;

(g) at all sites deemed environmentally or socially sensitive or special such as archaeological sites, areas adjacent to raptor nests, proposed IBP sites etc.; and

(h) at any other site or area designated by the Agency.

12. The Company's Quality Control Inspector shall keep a daily diary, log and photo journal, in a form acceptable to the Agency, noting the site work done, engineering, construction and environmental problems encountered, design changes implemented, instructions issued by the Agency field representative, etc.

13. The Company's Quality Control Inspector shall prepare a weekly summary report of the site work progress and problems noting all field engineering/environmental aspects of the work. The summary shall certify that, except as specifically noted, all work was conducted and installed according to the Agency approved plans and procedures.

Comment: The weekly report shall be acknowledged by the Agency field representatives not later than two days following the week for which the report was prepared.

14. The Company's Quality Control Group shall be responsible for the preparation of "as-built" plans of all aspects of the permanent installations and those temporary installations designated by the Agency (e.g. fuel tanks, wharf sites, water intakes etc.) As-built plans shall be prepared as construction proceeds.

15. The Company shall, on demand, provide the Agency with an up to date status report on the stage, quality and as-built status of any aspect of the project within 15 days of any such request.

Contingency Plans

Comment: The subject of contingency plans is dealt with in detail in various sections throughout this submission. The following general overview is designed to provide general direction only and to highlight the importance of various aspects of the plan.

16. The Company shall develop comprehensive contingency plans for various aspects of the project as outlined and as otherwise indentified by the Agency.

Comment: Contingency plans are required for things such as:

(a) fuel spills of various sizes and at various locations on land and in water along the Mackenzie River system, Delta and Beaufort Sea Coast;

(b) methanol spills on land and in water;

(c) spills or leakage of hazardous and toxic

(d) construction changes in response to conflicts with wildlife; and

(e) construction changes to respond to early breakup, insufficient snow/water for snow road construction etc.

Each contingency plan should be a self contained, separately bound document that deals with all aspects of the particular contingency including such things as:

(a) The person or persons within the Company who will be responsible for implementing the contingency plan, their office and home phone numbers, alternate contacts etc.

(b) The notification procedure that will be followed by the Company in dealing with the Agency, federal, territorial and local governments.

(c) The limits of current and readily available technology and the Company's ability to implement the plan for various scales of contingency event.

(d) The extent of damage that could occur for various scales of contingency events if the company's contingency plan was not successful.

(e) The priority of protective measures that will be implemented.

(f) The specific remedial measures that will be used including an appendix that documents the effectiveness of such measures as implemented elsewhere etc.

(g) The availability of equipment and trained manpower to implement the plan.

(h) The educational program, including field exercises, that will be used in anticipation of a contingency event.

(i) The extent of the Company's commitment and responsibility, as it understands them, if the event occurs.

Field Authority and Responsibility

17. At each activity associated with construction or operation of the pipeline the Company shall have a designated representative on site at all times during the work. Where a designated Company representative must leave the site or otherwise be unavailable, he shall notify the Agency's field representative in writing of the interim designated representative and this person shall assume all duties, responsibilities and powers of the designated representative.

18. The Company's designated representative on site shall immediately cease any work associated with the site or part thereof if requested to do so by the Agency's field representative.

19. The Agency field representative's instructions shall be final until they are superceded by written instructions to the contrary either by the field representative or his superiors.

20. The Company shall provide immediate, complete and free access to all parts of the project for all Agency representatives unless such access is a safety hazard in which case the Company shall so advise in written form which clearly describes the nature of the hazard.

21. Upon discovery of a situation that is, or could become, harmful in any way to the natural or social environment, the Company shall:

    (a) immediately notify the Agency;

    (b) take the appropriate remedial action; and

    (c) alter or stop the particular activity until a mitigative response can be implemented. Comment: The problem of notification of and responsibility for "upset" or

non-compliance situations is one that will have to be carefully addressed by the Company and the Agency because of the dilution of accountability inherent in a large subcontracted project. (see also "Enforcement")

22. The Company shall, upon notification or discovery of a environmentally hazardous situation, immediately assume all responsibility and costs to mitigate the situation and shall continue to do so until officially notified otherwise by the Agency.

23. The Company shall deploy all the equipment and personnel to mitigate a hazardous or emergency situation to the fullest extent of its ability and shall, if necessary, alter work on, or related to, the pipeline to do so. In responding to such situations, the Company shall keep an itemized account of all costs of men and equipment used.

24. Where the cause of an environmental emergency situation is found by the government to be unassociated in any way with activities relating to the pipeline, the government shall pay for all direct expenses at cost but shall not assume any responsibility, financial or otherwise, for the Company's loss of production.

25. One member of the Board of Directors of the Company shall, in rotation, visit each operating spread at least once a month. Prior to the visit, the Director shall be briefed by the Agency.

26. Upon written instruction by the governments field representative or upon notification by the Agency of an environmental situation of major concern, a member or members of the Board of Directors or senior management shall be made available to be on site for continuous periods as determined by the Agency.

27. Ten days after a visit to the project the Director(s) or senior management people shall submit a project status and compliance report to the Agency.

SOURCES OF INFORMATION

Organization

1. Transcripts, Exhibits, Basic Documents

CAGPL	Horte, V. (43:5587-92; 44:5826-28, 5736-48; 45:5881; 49:6508-10, 6712-13)
EPB	Gourdeau, E. (48:6340-44)

Contracts and Contractors

1. Transcripts, Exhibits, Basic Transcripts

CAGPL	Dau, P.H. (25:4640-43; 33:4281-84; 38:4925-32; 4936-42); Hemstock, R.A. (99:15044-47); Horte, V. (44:5731-36; 49:6510-18; 50:6636-37, 6726-40; 56:7851-52)
EPB	Templeton, C.H. (68:10224)
Exhibit	866: Thompson, A.R. 1976. Evidence on implementation; for CARC.

863: Skinnarland, E. 1976. Brief on authorities and procedures for implementation of stipulations forming part of a right-of-way permit for a Mackenzie Valley gas pipeline.

882: Zemansky, G.N. 1976. Environmental non-compliance and the public interest; for COPE.

Design Manuals

1. Transcripts, Exhibits, Basic Documents

CAGPL — Clark, J.I. (19A:2246-47; 21:2479; 24:2871; 26:3211; 39:5128); Hurd, L.G. (41:5332-35)

EPB — Templeton, C.H. (48:6330-34)

Quality Control

1, Transcripts, Exhibits, Basic Documents

CAGPL — Horte, V. (50:6704-26)

Contingency Planning

1, Transcripts, Exhibit, Basic Documents

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Field Authority & Responsibility

1, Transcripts, Exhibits, Basic Documents

CAGPL — Dau, P.H. (34:4457-67; 37:4782-83; 39:5161-63); Hemstock, R.A. (91:13821-24); Horte, V. (49:6611-13); Jakimchuk, R.D. (97:14817-20); McCart, P.J. (93:14088-100)

FH — Bouckhout, C.W. (100:15251)

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2. Reports

Gouvernement du Québec
1976 Recommendations preliminaires suite aux audiences sur la Baie James; préparé par le Ministre de l'environnement, par le Conseil Consultatif de l'environnement du Québec.

ENFORCEMENT

GENERAL RECOMMENDATIONS

The government should develop a hierarchy of measures that can be taken in situations where by accident, neglect or willful acts, the Company, its subcontractors or any individual, cause situations that violate or threaten to violate the terms, conditions, Acts, Regulations or Ordinances pertaining to the pipeline project.

DISCUSSION

A major problem for inspection personnel in any construction project is the lack of effective means of forcing the contractor to comply with the job technical specifications. This problem is compounded when "special" (non-trade) terms and conditions are introduced dealing with the natural and social environment -- items which workers and contractors may see as getting in the way of job progress. The contractors' people on site who face daily production problems quite logically and understandably gauge success by the rate of production. The job of building is their primary function, for which they are directly answerable. Most other things become secondary especially when the work environment is hazardous or severe, and creates stresses of an extraordinary sort. In such circumstances the kinds of circumstances that certainly prevail in the North, the contractor does not normally see preservation of the natural environment as a prime task, since so much of his energy is given over to mastering it. Stipulations regarding environmental protection rarely even appear in the contract documents.

Most inspectors have, in some form, the power to shut down a job for violations. However, this is a much talked of but rarely used power. It often causes more problems that it solves -- particularly for very large, capital intensive, tightly scheduled, seasonally dependent projects such as the proposed pipeline. Forcing such a project to stop is a very extreme measure and is only useful, if at all, in the most critical situations.

Fines are also a common penalty for non-compliance. However, in themselves they do little to solve the cause of the problem: they tend to get tied up in court and are not usually seen by the workers in the field as being of much consequence. Case studies of agencies using fines show that they are rarely applied.

Instead they are used as a public relations or bargaining tool in negotiations to persuade the offender to demonstrate more effort.

Job shut-downs and fines are generally ineffective in dealing with successive minor violations that in themselves do not warrant action but which, when compounded with other violations may lead to significant environmental degradation.

Both shut-downs and fines are often seen as indicators of the failure, not the success, of enforcement. This can lead to a situation where prosecution becomes unattrative to government because it amounts to an action which indicates the failure of government to efficiently control development. However the fundamental point remains, that even the very best stipulations can not produce results in the absence of adequate enforcement.

Fnforcement assures compliance. The task at hand is to develop a succession of measures of escalating severity that can be applied to individuals, groups, subcontractors, contractors and the Company (and perhaps the industry as a whole for violations to the social and natural environment. In so doing it is important to consider that non-compliance situations can be of different types such as:

(a) accidents,

(b) negligence or carelessness (or a non-recurring nature), and

(c) willfull non-compliance.

Each one of these non-compliance situations warrents a response. enforcement response. The response may vary from simply coping with the situation and initiating mitigative measures to issuing penalties.

The traditional owner-contractor relationship on most private projects is greatly complicated in the pipeline project North of 60°N. There the relationship is more of that between a landlord (government, and in an, as yet unspecified way, the native people) (Company)-contractor-subcontractor arrangement. Enforcement problems are complicated by this relationship, as s relating to responsibility and proof.

Both Applicants before the Inquiry have made assurances that the project can and will be built in an environmentally safe and

acceptable manner. They have undertaken many studies to substantiate this claim and have made various assurances to allay any misgivings not laid to rest y their studies. This should be viewed as a preliminary step in the formulation of specific stipulations that clearly define the responsibilities and performance standards, and hence the burden of proof that shall rest on the Company.

There is one particularly disturbing aspect of this. The Applicants' assertions, although well intentioned and made in good faith, are countered by the "case study" evidence lead by other participants. They have cited cases which bear some resemblance to this project. (CPR, James Bay, Alyeska, NW British Columbia, Northern Manitoba, seismic work etc.) and have shown how these projects can give rise to serious problems despit all the assurances to the contrary.

The challenges to the Company and government are clear. The first is to develop an adequate set of stipulations which, if complied with, will permit construction of an acceptable pipeline in the Arctic. It is submitted that the recommendations made in the various sections of this submission should be the foundation for such stipulations. Secondly, the government and the Company must develop an effective and forcefull means of assuring compliance. This compliance mechanism consists of project regulation by the Company and the government orientation and training (see previous sections) and, finally, enforcement.

RECOMMENDATIONS: THE GOVERNMENT

Proof

1. The government should assert in the right-of-way permit that the onus of proof of acceptability for all activities and matters undertaken by the Company either directly or indirectly shall rest entirely with the Company.

Comment: The government should assess and make clear to the Company at the time that the right-of-way permit is issued, the exact extent of responsibilities and liability that will apply to the Company in design approval and construction inspection activities.

If there is any doubt about the effect of any proposed activity or if the Company's documentation or performance does not

establish proof for its case, the Agency should assess the risks involved and establish a standard which, in so far as economics and technology permit, ensures that adverse effects of the activity are kept within acceptable limits.

Where the risk associated with an activity is such that reasonable economics and existing practicable technology cannot assure that short and long term adverse effects will be within acceptable limits, the Agency should prohibit the activity.

2. If the Company wishes to act in a way that does not conform to the stipulations, codes, terms or conditions, established by the government, the Agency should require that the Company demonstrate to the complete satisfaction of the Agency the merit of proposed actions and that such actions will not be any more harmful to the natural or social environments in the short or long term.

3. In assessing the cause of any adverse effect on, or adjacent to, the project, the government should specify that it shall be sufficient proof to establish that it was committed by an employee, agent, contractor or subcontractor (or employees thereof) of the Company, whether identified or not. The Company should be held liable for all penalties and actions as described herein.

Enforcement

4. The government should, in accordance with the "1972 Pipeline Guidelines" (p.4), require that the Company deposit a performance bond.

Comment: The bond should be sufficient to assure compliance with all stipulations contained in the agreement. (The sum of one percent of the value of the project has been cited before the Inquiry as a minimum).

5. The government should require that, upon request, the Company's contractors post a Field Activity Bond with the Agency.

Comment: The purpose of the Field Activity Bond would be to provide direct assurance from the contractor engaged in an environmentally or socially significant field activity, that the work will be done in the manner prescribed by the Agency. The

value of the bond would vary according to the nature of the work, the risks involved and the experience and past performance of the contractor.

A Field Activity Performance should be mandatory for the following:

(a) all activities on the Beaufort Sea Coast and on the North Slope of the Yukon;

(b) all main river crossings (i.e. those that are not built as part of the mainline pipeline contract but are contracted separately).

(c) all activities that take place within designated or proposed IBP sites, or socially or environmentally critical areas as identified by the Agency;

(d) all construction camps with a population equal to or exceeding 100 men;

(e) all compressor station sites; and

(f) other areas of activity such as fuel storage areas, waste disposal sites, wharves etc., as may be designated by the government.

6. If the Company or any of its contractors fails in any way to comply with the terms and conditions or the instructions of the Agency's field representative, the Agency should immediately arrange to have others carry out the necessary work to ensure compliance and should charge all costs so incurred plus a five percent administration fee to the Company.

7. The government should prescribe that the Company be responsible for inspecting the work of all its contractors and subcontractors to assure that it is done within the prescribed terms and conditions, codes, Acts, Regulations and field instructions. Where non-compliance situations exist the Company shall be responsible for implementing all necessary mitigative measures and shall be required to implement all penalties called for in ites contracts with the offender.

8. The authority to enforce all stipulations should be vested in the Agency's field representative, who should have the power to stop any activity which does not or will not comply with the terms and conditions. No work should recommence after a shut down until the Company has demonstrated conclusively that the problems associated with the shut down have been overcome.

9. The Agency's field representative should be empowered to enforce compliance in situations where the Company or its contractors are failing to perform in an environmentally or socially responsible way by:

   (a) requiring the Company to change its method of environmental and social inspection at a site; and

   (b) requiring that a senior management employee of the Company or its contractor be on site and remain on site to assume all responsibility for operations until environmentally responsible behaviour is demonstrated to the satisfaction of the Agency.

10. The government should develop a hierarchy of measures of escalating severity that can be applied to individuals, groups, subcontractors, contractors and the Company both in the field, in the corporate offices and in the courts for non-compliance situations that might arise due to:

   (a) accidents,

   (b) negligence or carelessness,

   (c) wilfull non-compliance.

   Comment: The intent of the enforcement measures, legal or otherwise, should be to respond to prospective and actual non-compliance situations in a way which:

   (a) immediately mitigates the situations by removing the cause and by initiating procedures that will remedy the damage done;

   (b) assigns immediate forfeiture of non-negotiable penalties that act as deterents;

(c) assigns penalties for violation to the specific individual or group involved; and

(d) assigns penalties that are proportional to the non-compliance situation and that escalate in severity with continued violations or with consistent non-compliance.

The responsibility for environmental protection of each individual, union and company must be viewed in the same light as responsibility for safety. Working in an unsafe manner is universally acknowledged as being unacceptable. Similarly, works must not be undertaken in an environmentally hazardous manner. As with safety, each individual who will be trained in environmental matters (see "Orientation and Training") has a clear environmental obligation. Therefore, the government should stipulate in the appropriate documents binding on the project that:

(a) all individuals associated with the project shall be liable to prosecution for violation of existing Acts, Regulations, Ordinances, Codes, terms, conditions, and stipulations, and therefore shall carry personal environmental insurance;

(b) in the event that environmental damage exceeds the ability of an individual or group to pay for restoration, all the Company's contractors and subcontractors, their unions and all persons working on the pipeline project shall carry <u>environmental insurance</u> equivalent to; in the case of companies and unions, five times the value of their total contracts or union dues over the life of the project; in the case of individuals, twelve times their avevage monthly income based on a 12 hour six day week;

(c) each person employed on the project by the Company or any of its contractors or by the government shall deposit with the Agency the equivalent of four days' pay (based on a 12 hour day) to be held in trust, with interest, as a <u>Personal Environmental/Social Damage Deposit</u>.This deposit shall be refundable with interest upon job termination or project completion except as noted below;

(d) workers dismissed from their job or officially reprimanded as a result of social or environmental infractions shall forfeit all of their Personal Environmental/Social Damage Deposit to the Agency.

Prosecution

11. The government should undertake to re-evaluate the adequacy for this project of all the penalties under legislation that will be administered by the Agency.

Comment: Most environmental legislation was developed without cosideration of a multibillion dollar project of the type proposed. Even with the recent increase in northern activity it is apparent that existing law is not sufficient when it comes to enforcement and prosection' This matter should be reviewed. Various points are made in this regard throughout the various sections of these recommendations and include such things as penalties for feeding and harassing wildlife, control of aircraft for environmental reasons, destruction of important wildlife habitat etc.

12. All the Agency's field representatives should be thoroughly trained in the methods of gathering evidence and expediting prosecutions for violations of stipulations relating to the pipeline project.

13. Concurrent with the granting of the right-of-way permit, the governnent should appoint a special crown prosecutor whose prime responsibility shall be to handle cases relating to the pipeline project.

Enforcement and Penalties

SOURCES OF INFORMATION

1. Transcripts, Exhibits, Basic Documents

Berger	(68:10217; 95:14512, 14518-19; 109:16686-88)
CAGPL	Banfield, A.W. (95:14431); Hemstock, R.A. (91:13822-23); Jakimchuk, R.D. (96:14684-85); Horte, V. (43:5583-84; 44:5748-59; 49:6614-21; 50:6622-23, 6667, 6701-03); McCart, P.J. (94:14209; 97:14809)
CARC	Lent, P.C. (111:16948-49); Novakowski, N.S. (102:15616-17)
EPB	McTaggart-Cowan, I. (48:6389; 108:16422, 16452-55); Templeton, C.H. (48:6440-41; 68:10188-93, 10208-18; 107:16376; 108:16474-76)
Comm. C.	Mossop, D.H. (138:21043-69); Norton, D.W. (138:21043-69); Simmons, N.M. (138:21043-69); Stephen, W.J. (138:21043-69)
Exhibit	872: Testimony of M.H. Rogol 881: Beakhurst, G.J. 1976. Problems of regulating industrial activity in the Canadian North. 882: Zemansky, G.M. 1976. Environmental non-compliance and the public interest.
EGNP	Expanded Guidelines for Northern Pipelines.

2. Reports

Estrin, D. *et al.* (ed)
1974 Environment on trial: a citizen's guide to Ontario environmental law; Environmental Law Research Foundation, pp311-324.

Gouvernement du Quebec
1976 Recommendations preliminaires suite aux audiences sur la Baie James; Counseil counsultatif de l'environnement.

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Transcripts, Exhibits, Basic Documents

Berger	(67L9873-9876)
CAGPL	Horte, V. (43:5705-19); Longlitz, D. (70:10541); Marshall, J. (97:14749-71)
EPB	McTaggart-Cowan, I. (107:16337); Templeton, C.H. (67:9873:74)

ENVIRONMENTAL AND SOCIAL TRAINING PROGRAM

GENERAL RECOMMENDATIONS

Programs should be established well before the start of pipeline construction to provide Company (and contractors') staff at all levels with an understanding of the environmental and social circumstances of the pipeline project. All workers should be made familiar with Company and government regulations concerning social and environmental matters, and the penalties for contravening these regulations.

Such programs should be developed and coordinated by an independent and educational organization, funded by the Company, responsible to the Agency and working in close cooperation with Company, union, native, government and environmental groups.

DISCUSSION

Both Applicants have agreed that some form of environmental education would be provided to all field personnel. The Environment Protection Board has been very specific in outlining the need for such programs and in suggesting how this should be done.

While the details of program development should be left to the independent organization chosen to do the work, it is essential that the program be flexible enough to meet the varied requirements of different groups within the pipeline personnel, particularly in the case of environmental training. Thus environmental training for design engineers should have a different emphasis and perhaps content from training given to welders or equipment operators and those supervising the work on-site will have yet another requirement for training. All environmental training should have a practical, immediate orientation, focusing directly on regulations designed to protect the environment and on the problems that would arise if those are not followed.

The training of pipeline personnel in the social situation of the Mackenzie Valley has not received as much consideration in the evidence as environmental training, and yet the pipeline project's potential for creating social dislocation is at least as great as the threat it poses to the physical or biological environment. The Agency should ensure that training relating to

social issues is given equal status with environmental training. Again, the orientation should for the most part be practical and related to specific regulations.

The problems of delivering such training programs will be similar to these of environmental programs. It seems sensible that they both be undertaken by the same independent organization.

To succeed, any program of the kind indicated will depend a great deal on the cooperation of all parties. The Agency must be empowered to ensure that these training programs, once developed, are carried out in accordance with terms and conditions that are laid down.

RECOMMENDATIONS

1. The Company shall hire an independent educational organization to develop and conduct an environmental and social education program for all persons (project and government employees) associated with the pipeline and related projects (in design offices as well as field positions) during both construction and operation of the pipeline.
2. Such a program shall commence operation at least one full year before the start of pipeline construction.
3. The environmental-social education programs shall incorporate the specific recommendations of the Environment Protection Board as set forth in "Environmental Training of Pipeline Construction Workers", and shall include material developed to cover social factors of particular concern to the region and its people.
4. All tender documents for sub-contractors shall include the requirement that all staff receive the appropriate environmental and social training.
5. While short, introductory lectures for workers will be essential, it is recommended that the emphasis of the programs be on a continuous series of lectures, audio-visual presentations and discussion groups held with the workers in the camps and on-the-job.

6. The orientation of the contents of the training programs is to be practical, stressing the kinds of social and environmental problems the individual pipeline worker would encounter while working in the North.

Comment: The implementation of an effective education program will be a substantial undertaking that must receive priority within the Company. It is the key to responsible environmental and social performance. Some possible sources of assistance in establishing such a program might include: (a) Trent University Native Studies Program, (b) Pallisades Ranch, Jasper (Parks Canada Training School), (c) University of Alberta Arctic Summer School, (d) Northern Alberta Institute of Technology's Hinton Forestry School, (e) Frontier College, Toronto, (f) The Saskatchewan Institute of Technology, (g) Cornell University's Conservation Education Department, and (h) The Thorne Ecological Institute, Aspen, Colorado.

7. The ultimate authority for all matters relating to the environmental and social education program shall be the Agency. It is expected that the Agency would set up monitoring procedures for the program that would involve special interest groups. In order to prevent biases and the wrong kinds of impressions from infusing such material, it is particularly important that the native people should play a significant role in developing any material that refers to them.

SOURCES OF INFORMATION

1. Transcripts, Exhibits, Basic Documents

CAGPL Dau, P.H. (33:4283; 37:4784-85); Gunn, W.H. (97:14804-05); Hemstock, R.A. (95:14505-08, 14521-22); Horte, V. (49:6604-05); Jakimchuk, R.D. (97:14818); McCart, P.J. (97:14810)

FH Blair, S.R. (58:8150-51); Bouckhout, C.W. (88:13213-15; 100:15250-58); Mirosh, E.A. (66:9799; 67:9991-96, 10028-31)

EPB Craik, D.W. (46:6079-80); Gourdeau, E. (48:6334-40, 6354-56, 6382-84; 109:16605-11); Templeton, C.H. (47:6293-98; 107:16328; 108:16469-70; 109:16605-11)

Comm.C. Longlitz, D. (72:10702-11)

EGNP Environmental Guidelines pp. 16, 23

CAGPL Application (as amended to 8 March 1976) Sections: 14.d.N., 2.2.8, 6.1.1.; 13.a. 2.3

FH Application (as amended to 23 August 1976) Section: 5D-5.10.1

2. <u>Reports</u>

Oetting, R. <u>et</u> <u>al</u>.
1974 Guidelines for environmental training of pipeline construction workers, for the Environment Protection Board.

Environment Protection Board
1974 Environmental impact assessment of the portion of the Mackenzie gas pipeline from Alaska to Alberta; Vol 1, Sect. 33, p. 45.

PROJECT OPERATION

OPERATION AND MAINTENANCE OF THE PIPELINE: INTRODUCTION

GENERAL RECOMMENDATIONS

The Company shall operate and maintain the pipeline in a safe condition, and in a manner that will minimize impacts to or disturbance of the environment. Every effort shall be made to perform all maintenance and repair work during winter. Work to be done in the summer season shall be restricted to minor works, temporary repairs (to be followed by permanent repairs in winter), emergency repairs and works which by their very nature can only be done in summer.

The objective of the maintenance and repair program shall be the prevention of unsafe, unstable or emergency situations. The Company shall keep records of all operation, inspection, maintenance and repair activities, for as long as the pipeline remains in service.

The Company shall develop detailed plans for operations and maintenance of the pipeline system as part of the final design. These plans shall be submitted to the Agency for approval. The plans shall clearly demonstrate the manner and extent of environmental concerns taken into consideration.

Prior to commissioning of the pipeline, the Agency should review the concerns, recommendations and procedures discussed in this report in the light of the experience gained during the construction period and prepare revised terms and conditions for the operational phase of the pipeline.

DISCUSSION

Continuous activity, in the form of inspection, maintenance, repair and resupply, is a normal feature of the operational phase of any large engineering project, and particularly a transportation system such as a highway, railroad or pipeline. The level, nature and location of such activities fluctuate from year to year, season to season and day to day. In general, a fairly high level of maintenance activity is required during the first few years of operation until some form of equilibrium is reached between the system and its environment. This is followed by many years during which seasonal fluctuations in activity dominate. In this period, there are years of more intense activity associated with rebuilding or extending part of the system, or of major repairs as wear and tear begin to appear. The

final years of a system's life are often marked by more frequent trouble since the cost of major repairs is not generally worthwhile. In a highly regulated industry, such as pipelining, the problems of this final period are not too severe.

It must be recognized that all this activity throughout the operating life of the pipeline is essential to the continued safe operation of the system. While some of this activity could have negative implications for the environment, it is essential to the pipeline and the approach must be to minimize environmental impacts. This may be done by restricting the time of year of certain activities, requiring that special vehicles or equipment be used, requiring more hand work and less machine work, requiring planning input by professional biologists etc.

The activities noted above -- inspection, maintenance, repair and resupply -- each comprise numerous sub-activities, each with its own propensity for impact on some aspects of the environment. One feature that is common to all the activity groups is a requirement for the continued movement of men, equipment and materials from one place to another. The impacts of this are of great concern and are most difficult to regulate. Other aspects of the inspection and maintenance of the system have the objective of keeping the pipeline and the right-of-way in a safe and stable condition. This in itself has positive implications for the environment, as a failure of the line or the right-of-way followed by a repair has considerably more potential for disturbance, particularly if it occurs in summer time, or at the peak of migration of an important group of mammals, birds or fish.

One inherent difficulty with the proposed monitoring and maintenance approach is the lack of year round access along the entire pipeline right-of-way. It may be impossible to rectify some of the problems detected by inspection, unless one is willing to accept the major damage associated with moving heavy equipment across permafrost terrain in summer or through important wildlife areas during critical periods. Summertime repair work is seen as the major environmental problem during operation of the pipeline. This concern provides the main justification for imposing standards and regulations on any Mackenzie Valley pipeline that go beyond present practice. This does not, however, eliminate the need for inspection, maintenance and contingency plans.

It must also be recognized that there is a minimum level below which the activity must not drop, otherwise the risk of an emergency situation increases quite sharply. This holds even in areas and times of extreme environmental sensitivity. If any attribute of the environment is so sensitive that this minimum level of activity is unaccepable, then the pipeline or facility concerned must be relocated to a less sensitive area or redesigned in a more conservative manner.

The need for ongoing inspection and maintenance or repair is particularly great in all parts of the pipeline system affected by surface drainage, streams and rivers. Although river processes have been the subject of many extensive research efforts, they remain unpredictable. This is particularly so for sub-arctic and arctic rivers, which are characterized by some processes not encountered elsewhere, such as the formation of icings, thermal erosion of ice-rich permafrost banks etc. If river related aspects of the pipelines were to be designed for the worst conceivable situations, the many unknowns would force the Applicants to adopt such massive and costly engineering measures that the projects would likely be uneconomic. It is present engineering practice to accept a certain risk of failure in the design of most river related facilities, such as bridges, culverts, dikes, training works etc., with major dams being the main exception. Some river processes are catastrophic in the sense that they are both unpredictable and unalterable once they occur. They run their course and whatever damage they do has to be repaired afterwards. Extreme floods and large ice jams fall into this category. An effective, well equipped contingency organization is the proposed tool for dealing with this type of event.

Some other river processes are also unpredictable on a long term basis but, by taking place slowly, become predictable in the short term. Bank erosion, channel shifting, migration of deep scour holes and frost heave under rivers are processes of this type. Careful monitoring of stream channels, combined with preventive maintenance are the appropriate tools for dealing with them.

Another area of concern relates to a phenomenon common to most engineering projects, namely the tendency for an abrupt change of personnel between the design and construction phase and the subsequent operating phase. So, since careful monitoring is an integral part of the operational phase and particularly the

solutions proposed for some river related problems, procedures need to be set up to assure that the assumed monitoring programs are in fact carried out and, more importantly, that the engineers in charge of these monitoring programs have the specialized knowledge of river processes to recognize any impending troubles. This problem also arises in other aspects of the maintenance of the pipeline, but it is most acute in this area of river and stream engineering. There can be little doubt that intelligent monitoring combined with preventive maintenance can minimize environmental damage during operations.

The general approach to operations and maintenance of the two Applicants is very similar. Both propose to have the pipeline controlled from a "gas control centre"; Foothills plans to locate in Yellowknife, while Canadian Arctic Gas plans to locate in Calgary. For routine maintenance purposes, both Companies plan to divide their systems (north of 60°N) into three districts, with offices and repair shops located in Inuvik, Norman Wells and Fort Simpson. Foothills plans to locate a main maintenance and supply base at Fort Simpson. Arctic Gas proposes to have the main office for the northern division in Inuvik.

The most important differences between the two Companies is their general approaches to transportation. Arctic Gas proposes to have an airstrip at all except two of the compressor station sites. Thus resupply, maintenance and repair work will be done from these sites, and travel to work sites will be by low-ground pressure vehicles and small helicopters travelling along the right-of-way. Foothills does not propose to build any airstrips at compressor sites. Consequently, much greater reliance will be placed on the use of helicopters, including large, heavy-lift machines. In addition, more over-land travel will be required, and not all of this will be along the pipeline right-of-way (see also "Roads, Airstrips and Helicopter Pads").

The following sections of this report deal with the major activities required, outside of compressor station sites and operational bases, during the operating phase of the pipeline. The sections are:

(a) Line and Station Start-up

(b) Line Patrol and Inspection

(c) Routine Maintenance of the Pipeline and Right-of-way

(d) Emergency Repairs to the Pipeline and Right-of-way

(e) Transportation Requirements for Operation and Maintenance.

Specific recommendations follow each section.

SOURCES OF INFORMATION

1. <u>Transcripts, Exhibits, Basic Documents</u>

CAGPL	Carlson, M.E., Fielder, D.E. and Hurd, L.G. (40-42:5180-5528)
FH	Hushion, D.H., Littledale, R. and Mirosh, E.A. (68:10038-10128)
CAGPL	Application, Section 13.b
FH	Application, Section 3F

2. <u>Reports</u>

J.E. Rymes Engineering Ltd.
1975 Preliminary report on work and transportation equipment; for C.A.G.S.L.

LINE AND STATION START-UP

GENERAL RECOMMENDATION

The Company shall schedule and carry out the start-up operations for the pipeline and compressor stations at times and in a manner that will minimize disturbance to people, birds and mammals.

DISCUSSION

The start up of a pipeline involves an intricate series of activities mainly at the meter and compressor station sites, with perhaps some activity at intermediate valve sites. The sequence of events is complex and comprises: start-up of the gas control centre, testing and start-up of main meter stations, purging the line of natural gas on a sectional basis, testing, purging and start-up of each compressor station, testing and start-up of station services and utilities and transfer to remote control. If the start-up plan is to succeed, each of these has to be performed successfully by the appropriate deadline.

Both Applicants propose to use essentially the same plans and procedures for start-up. There are three main areas of concern in these plans: noise, human activity and timing. The problems of the noise associated with line and station purging are discussed in "Noise", "Compressor Station Noise" and "Blowdown Noise".

The problems of human activity arise because of the complex nature of the start-up procedure. All the staff involved will be in radio contact with the gas control centre. However, all the staff at meter and compressor stations and valves have to be taken to those locations, which will presumably involve aircraft movements. During the actual start-up, which may take a few days for each section between compressor stations, there will also be a considerable amount of air traffic along the pipeline and in and out of the various facilities. Thus the whole start-up operation could take a couple of months for the main line, and another month the following year for a Prudhoe Bay lateral. Foothills' revised Application allows three months for start-up of the main line alone.

The timing problem arises because, once construction is finsihed, the Company will wish to put the line into operation as soon as possible. The concern is that this noisy, busy procedure should not take place at a time that would disturb the mammals and birds

of the region. Foothills has indicated, in its revised Application, that start-up of the main line will be done in the autumn of construction year 5, with additional compressor stations started-up in the autumn of years 6, 7 and 8. No information is available on when Arctic Gas propose to start-up its line.

RECOMMENDATIONS

1. The Company shall develop a preliminary plan for line and station start-up as part of final design. A final plan shall be developed well ahead of the completion of construction of the pipeline. Both plans shall be submitted to the Agency for approval.

2. Line and station start-up shall comply with the restrictions on noise generation described in "Noise", "Compressor Station Noise" and "Blowdown Noise".

3. All people in the communities near the pipeline shall be warned before start-up commences. The warnings shall indicate the nature, time and amount of noise likely to be heard in or near the community and in the country between communities. The community warning procedure shall be submitted to the Agency for approval beforehand.

4. All aircraft and other vehicles used in the start-up procedure shall comply with the restrictions described in the section on "Transportation Requirements for Operation and Maintenance".

5. Start-up shall be scheduled at a time when no avoidable disturbance to birds or mammals will result. It is expected that the start-up will be done in autumn.

SOURCES OF INFORMATION

1. Transcripts, Exhibits, Basic Documents

CAGPL	Horte, V.L. (45:5955-56); Hurd, L.G. (40:5224-25; 42:5431-37)
FH	Hushion, D.H. (68:10095-97)

CAGPL	Application, Sections 13.a.2.3.1, 13.b.4, 14.d.N.5.3.2
FH	Sections 3D-1.2, 3F-4, 5D-4.4.6

LINE PATROL AND INSPECTION

GENERAL RECOMMENDATIONS

The Company's regular inspection and line patrol program shall cover all lands used by or in the care of the Company and not merely the pipeline right-of-way. The primary purpose of such inspection shall be to detect aberrant conditions so that maintenance and repairs may be made.

All line patrols and inspections shall be done in such a manner as to have the least possible impact on wildlife, fish and terrain. Environmental concerns shall be given due consideration along with the risk of any engineering problems developing when determining the nature and frequency of inspections.

Recognizing that environmental requirements may constrain the frequency or closeness of any inspection, the Company shall design and construct the pipeline and associated facilities in a conservative manner. Drainage and erosion control devices, slope stabilization measures, river crossings etc., are of particular concern in this regard.

DISCUSSION

Regular inspection of major operating pipelines is standard practice in North America. Such inspections are a requirement of the CSA standard for gas transmission and distribution piping systems (CSA Standard Z184) and of the Gas Pipeline Regulations (NEB 1974). The purpose of the inspection system on an operating pipeline is to detect aberrant conditions as early as possible, so that corrective measures may be taken before a serious or even emergency situation arises. The emphasis is on the prevention of trouble. This is achieved by frequent observation of the system visually or with the aid of instruments. Along a pipeline right-of-way, this observation is normally accomplished by flying along the right-of-way at low altitudes in a light fixed wing aircraft -- the line patrol. This is supplemented by patrols in vehicles appropriate to the terrain conditions or even foot patrols. In addition, certain instrumental observations are also made.

Arctic Gas plans monthly line patrol flights generally, with weekly flights during critical times such as the main snowmelt period when drainage and erosion control measures are most likely to fail. Foothills' proposals are apparently similar. There are two groups of concerns arising from the proposals for line

patrols and inspection. One is the potential for disturbance by the actual line patrol activity, the other is the consequences of insufficient or inappropriate inspection.

The first category includes items such as disturbance of mammals or birds by low flying aircraft, or disruption of drainage and erosion control devices by careless operation of vehicles. The impacts of these items can be minimized by regulating the type and use of aircraft or vehicles, and by appropriate design of erosion control structures. The second category covers failure to identify evidence pointing to things such as stream channel shifts that may expose the pipe, pipe movements due to frost heave, thaw settlement or buoyancy problems, development of ice jams or surface icings, corrosion due to failure of the cathodic protection system, gas leaks and slope failures on or adjacent to the right-of-way. The solutions to these problems are engineering in nature; they include measures such as instrumental surveys of pipe position, sounding of river channels in the vicinity of the pipeline crossings, regular measurement of sediment concentrations in streams, and a program of regular aerial photography of key localities, such as river crossings, ice jam areas and areas of springs and surface icings. Provision for these, in the sense of survey datum points, bench marks or ground control for aerial photography, should be made at the time of construction. At river crossings, underwater inspection by divers may become necessary.

Special attention also has to be paid to surface drainage through breaks in the backfill mound and surcharge berm, through culverts, under roads, and around airstrips as well as along the right-of-way in general.

If the restrictions on regular aerial line patrol mean that adequate visual inspection cannot be achieved, the use of aerial photography, or other remote sensing systems should be adopted.

As the various impacts associated with line patrol and inspection cannot be eliminated, if the pipeline system is to be operated safely, the objective of the terms and conditions is to minimize the impacts, either by regulation of the nature of the activities, their frequency and spacing, or by constraints on the seasonal performance of the various activities.

RECOMMENDATIONS

1. The Company shall carry out regular visual inspections of the pipeline right-of-way, using small fixed wing aircraft. The frequency of such flights shall not exceed one per week. The aircraft shall be operated in accordance with conditions described in the section on "Transportation Requirements for Operation and Maintenance". Helicopters shall not be used for line patrol in critical wildlife areas.

2. The Company shall supplement the aerial line patrol as necessary, with ground patrols using low ground pressure vehicles or persons on foot. Foot patrols may be supported by vehicles or helicopters. Ground patrols across the Mackenzie Delta may be done by boat. Vehicles, boats and helicopters shall be operated inaccordance with conditions described in "Transportation Requirements for Operation and Maintenance".

3. To the greatest extent possible, vehicle patrols shall be done in the winter season. Ground patrols in summer shall be done in conjunction with and with the approval of the relevant territorial wildlife agency and/or fisheries agencies.

4. To the greatest extent possible, instrumental surveys for gas leaks, pipe movements, erosion etc., shall be done in the winter season.

5. Special programs of inspection and monitoring are to be produced for all designated stream crossings, all slopes where stabilization works are carried out as part of the construction of the pipeline, and for any other sites specifically requested by the Agency. The plans are to comply with the requirements listed in "River Crossings" and "Slope Stability".

6. On 31 August of each operating year, the Company shall submit reports to the appropriate government departments and agencies summarizing the findings of the previous year's monitoring of designated stream crossing and other special sites.

7. Line patrol and inspection procedures prior to the completion of construction shall be approved and supervised by the Agency.

SOURCES OF INFORMATION

1. Transcripts, Exhibits, Basic Documents

CAGPL	Carlson, M.E.; Fielder, D.E.; Hurd, L.G. (40-42:5180-528)
FH	Holtsbaum, W.B. (63:9149); Hushion, D.H.; Littledale, R., Mirosh, E.A. (68:10038-128)
CAGPL	Application; Section 13.b.4.5.2
	Responses; Question 55
FH	Application; Section 3F-5.4.
PAAG	Section 9.5

2. Reports

Canadian Standards Association
1973 Code for gas transmission and distribution piping systems. (CSA Standard Z184-1973).

National Energy Board
1974 Gas pipeline regulations.

1976 Transcript, Mackenzie Valley Hearing, GH-1-76; pp. 2982-84.

ROUTINE MAINTENANCE OF THE PIPELINE AND RIGHT-OF-WAY

GENERAL RECOMMENDATIONS

The Company shall maintain the pipeline and the right-of-way in a safe and stable condition in order to reduce the requirement for repairs and the potential for environmental disturbance. In the planning, organization and performance of maintenance and repair work the Company shall give due consideration to environmental protection.

Protection of the environment shall be a prime consideration in the selection and placement of work equipment, supplies and material for the routine maintenance and repair of the pipeline and the right-of-way

DISCUSSION

Regular maintenance and ongoing repairs are essential to any pipeline project. The maintenance and repair procedures for this project have a potential for great environmental impact. The maintenance activity itself, and particularly travel to or along the right-of-way can disturb animal populations, destroy vegetation, disrupt drainage patterns and lead to erosion and the discharge of sediment into waterbodies. On the other hand, inadequate or insufficient maintenance can lead to more serious or even emergency situations.

Impacts of routine maintenance on the pipeline cannot be completely eliminated. Hence the objectives of the terms and conditions must be to regulate the activities in such a way as to minimize the impacts, and where possible move them to less sensitive times of year. Because of the unpredictable nature of the activity, the recommendations can only be in the form of guiding principles.

The great majority of right-of-way maintenance jobs are likely to be related to erosion control, revegetation, frost heave and pipe buoyancy. These are all problems which probably do not immediatly endanger the continuity of gas supply. When and how this type of maintenance work is to be undertaken can be regulated. Some maintenance work will be required in response to problems that pose an immediate threat to the continuity of supply -- for example an impending massive failure of a river bank or valley wall. In the face of such an emergency situation,

only the manner of the response is subject to regulation, and not the timing. The recognition of emergency situations is discussed in the following section of this report; "Emergency Repairs to the Pipeline and Right-of-Way".

In the case of non-immediate right-of-way maintenance and repair work there is a real danger that the Company will allow economic considerations to dictate maintenance decisions. This is clearly stated in the report "Drainage and Erosion Control Measures, Description and Proposed Design Principles" (NESCL, 1975), where to spacing of backfill mound breaks is computed by minimizing the combined costs of initial construction and maintenance. There is some evidence indicating that stream crossings will be designed on the same basis. This approach is totally unacceptable from an environmental point of view.

Because right-of-way maintenance is environmentally disruptive it should therefore be minimized as much as reasonable economic constraints permit. Maintenance or repair in summer is particularly damaging and it is therefore desirable to do as much maintenance as possible during the winter following recognition of a potential problem. The basic design philosophy has to be based on meeting certain probabilities of failure, as specified in the section of this report dealing with "Crossing Design Flows and Levels".

Concerns related to how maintenance or repair work is executed are less severe, and mainly involve organization. The Company's maintenance staff has to include some personnel trained to recognize environmental problems and they need to be placed in positions of sufficient authority to assure that their concerns are heeded. Bth applicants have made commitments in this regard.

The general proposals of both Canadian Arctic Gas and Foothills are quite similar in regard to routine maintenance repair of the project. Both companies propose to do as little ground work as possible during the summer, and to restrict the use of vehicles and equipment to winter as far as possible. Discussion of the selection and use of vehicles for maintenance purposes is included in the section of this report dealing with "Transportation Requirements for Operation and Maintenance".

RECOMMENDATIONS

1. All maintenance and repair operations shall be undertaken in a manner, at times and using equipment and transportation modes that will minimize the impact of the activity on the physical and living environment.

2. Major maintenance operations and repair activities shall be scheduled, as far as possible, in winter; essential work only should be undertaken in summer.

3. The Company shall develop provisional maintenance plans on a regional basis as part of the final design of the pipeline. Final maintenance plans shall be developed prior to commissioning of the pipeline. The plans are to be submitted to the Agency for approval and for the approval of the government departments and agencies that will be responsible for the regulation of the pipeline during its operating life.

4. Site specific repair plans for non-emergency repairs shall be developed for all designated stream crossings, including dual-pipeline river crossings, and for all other sites requiring special inspection or monitoring programs. Such plans shall be submitted to the Agency for approval prior to commissioning of the pipeline.

5. On August 31 of each operating year the Company shall submit reports to the appropriate government departments and agencies describing all maintenance work performed during the preceding year and giving a detailed outline of maintenance plans for the following year.

6. The government may request maintenance work even if no damage is apparent as yet, and if the Company should fail to execute the work as requested, the government may have it done by others at the expense of the Company.

7. During maintenance of the pipeline and right-of-way, special attention shall be paid to:

   (a) the status of the revegetation program;

   (b) the stability and effectiveness of the drainage and erosion control devices;

(c) the stability and effectiveness of sediment trapping devices; and

(d) the repair of all damage whether natural in origin, caused by the Company or caused by other parties.

This shall not be taken to limit the liability of other parties for damage resulting from illegal or improper use of the pipeline right-of-way.

SOURCES OF INFORMATION

1. Transcripts, Exhibits, Basic Documents

CAGPL	Carlson, M.E.; Fielder, D.E.; Hurd, L.G. (40-42:5180-5528); Clark, J.I. (80:1147); Hollingshead, G.W. (21:2435); Williams, G.L. (83:12405)
FH	Hushion, D.H.; Littledale, R. (68:10038-128); Mirosh, E.A. (64:9405; 68:10038-128)
CAGPL	Application; Section 13.b.5.
FH	Application; Section 3F-5.

2. Reports

NESCL 1975	Drainage and erosion control measures, description and proposed design principles (NESCL for CAGSL). (Exhibit 121)

EMERGENCY REPAIRS TO THE PIPELINE AND RIGHT-OF-WAY

GENERAL RECOMMENDATIONS

The Company shall prepare detailed contingency plans and procedures for the rapid repair, with a minimum of environmental disturbance, of failures or impending failures of the pipeline (leaks or ruptures), the right-of-way (washouts or slope failures), or lands under the care of the Company.

The staff of the Company shall be thoroughly trained and rehearsed in the execution of such plans and in techniques to minimize environmental disturbance.

Protection of the environment and the activities and property of local people shall be prime considerations in the development of all contingency plans, in the selection and placement of work equipment, supplies and material for the emergency repair of failures of the pipeline or right-of-way, and in the response of the Company to any emergency situation which may arise.

The need for emergency access to and along the right-of-way with a minimum of environmental disturbance shall be a consideration in the development of all contingency plans and in the location and design of the pipeline in general, and of the drainage and erosion control measures in particular.

DISCUSSION

For the purpose of this report, an emergency situation is defined as any situation which a) interrupts or threatens to interrupt the continuity of gas supply, b) affects or threatens to affect any civil works associated with the pipeline system or, c) creates or threatens to create a situation which would have been deemed unacceptable during the original construction of the pipeline on the right-of-way, and on or adjacent to all lands under the control or in the care of the Company. An emergency situation warrants a prompt remedial response by the Company.

Emergency repairs to the pipeline or the right-of-way have considerable potential for causing disturbance and damage to the natural environment. This potential cannot be eliminated if the project is to go ahead and the pipeline is to be operated safely. Thus the objectives of the recommendations must be to reduce the impacts to a level considered acceptable. The recommendations have to recognize that it is not possible to predict the location

or timing of an emergency situation. If a failure or other problem can be predicted in either time or space, an emergency situation should not be permitted to develop.

The general approach to contingency planning is similar for both Arctic Gas and Foothills, in that work equipment and supplies will be stockpiled at intervals and will be moved to the site of the emergency when needed. Arctic Gas plans to have good supplies of vehicles and equipment at each compressor station along the Prudhoe Bay lateral (Coastal route), at each district headquarters and at approximately every second compressor station along the Mackenzie Valley. It proposes to move heavy equipment and supplies to the work site along the right-of-way, using low ground pressure vehicles. Foothills plans to have its main store of equipment and materials only at the district headquarters and plans to move them to the work site by truck or low ground pressure vehicle as appropriate. Both companies propose to move men, tools and lightweight supplies to the work site primarily by helicopter. Arctic Gas will move men to the compressor station stockpiles by fixed wing aircraft.

Both companies propose to prepare detailed contingency plans to cover all emergency situation they foresee. Their plans are described in their respective applications and were discussed at length during the hearings. Again the approach is similar. Environmental information relative to the right-of-way is to be compiled before and during the construction of the pipeline and incorporated as part of the contingency plans. These plans will be kept up to date so that they reflect the true status of all equipment, staff, outside assistance available and environmental concerns. Furthermore, staff and government wildlife authorities and other environmental experts will be consulted as necessary. The staff biologists will be made available immediately, via the communications system.

The contingency plans are to be developed on a regional basis, with special sections to cover the different seasons of the year and the movement and behaviour of important animal populations within each region. The contingency plans cannot hope to be totally site-specific about the hundreds of locations where an emergency situation may arise. Thus the approach will be to prepare master plans, including detailed descriptions of several typical situations at different seasons. Special plans for emergency repairs at river crossings were also described. Staff training will be a part of the planning process.

Considerable evidence was produced about methods of transporting men and equipment to the site of an emergency repair. Four main modes of transportation will be relied upon: fixed wing aircraft, helicopters, low ground pressure vehicles and air cushion vehicles. These are discussed further in the section dealing with "Transportation Requirements for Operation and Maintenance". Some special equipment, with an amphibious capability, would be necessary for repairs to a Cross-Delta pipeline.

Materials required for emergency repairs will be stored as indicated above, at compressor stations and district headquarters. Foothills also proposes to locate stores of equipment near major river crossings. Both companies will require access to borrow material -- mainly gravel -- for repairs to the right-of-way and for backfilling after a pipeline repair.

Pipeline ruptures at stream crossings are unlikely but not impossible. Canadian Arctic Gas consider the risk sufficiently large, and the emergency repair job sufficiently difficult, to have accepted dual pipes for several major river crossings. For purely economic reasons Foothills propose to build single-pipe crossings only. Contingency plans are only needed for single crossings. This does not mean that repair plans need not be prepared for all river crossings. By way of an example, Arctic Gas outlines the emergency repair plan for the Great Bear River crossing near Fort Norman in its response to PAAG question 54.

RECOMMENDATIONS

1. The Company shall respond promptly to emergency situations involving threats to the environment or the activities of local people, as well as to the pipline or other Company property. The response shall have as its two prime objectives:

   (a) the repair or the prevention of the failure of the pipeline or right-of-way, and

   (b) the minimization of damage to and disturbance of the environment.

2. The Company shall prepare comprehensive contingency plans to cope with all forms of emergency situations occurring in different places and at different times of the year. The

plans should allow for emergencies developing during adverse weather or communications conditions, and for more than one emergency occurring at the same time.

3. Provisional contingency plans shall be developed as part of the final design process, and final contingency plans shall be prepared and approved by the appropriate authorities prior to the commissioning of the pipeline system.

4. The plans developed shall clearly demonstrate the manner and extent to which environmental protection has been considered in the selection and placement of vehicles, equipment, supplies and material for the emergency repair of the pipeline or the right-of-way.

5. Site-specific contingency plans shall be prepared for each single-pipe crossing of a designated major river. Provisional plans are to be prepared as part of the preliminary design of each crossing, with final plans prepared prior to commissioning of the pipeline.

6. Regional contingency plans shall be prepared, on the same basis, for all other designated stream crossings, the areas of potentially unstable slopes, the areas near or susceptible to damage by stream or surface icings and for areas with a potential for failure as a result of seismic (earthquake) events.

7. The staff of the Company shall be thoroughly trained and rehearsed in the execution of the contingency plans, and in techniques to minimize environmentatl disturbances. The training is to include periodic, realistic field drills and other training as required.

8. Following completion of any emergency repairs, clean-up and restoration measures shall be taken. If appropriate, temporary measures only shall be made at the time of the emergency, with permanent measures being done at a time of year suitable from an environmental point of view.

9. The Company shall make and keep detailed reports on all emergency repair activities.

10. Each emergency incident or accident shall be reported in accordance with Sections 85 and 86 of the Gas Pipeline Regulations (NEB 1974). In addition, on 31 August of each operating year, the Company shall submit summary reports to appropriate government departments and agencies, describing all emergency repair activities undertaken during the preceding year, and indicating what steps have been taken to try and prevent similar emergencies from arising in the future.

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National Energy Board
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TRANSPORTATION REQUIREMENTS FOR OPERATION AND MAINTENANCE

GENERAL RECOMMENDATIONS

All transportation and work equipment used during the operating period of the pipeline shall be selected, deployed and operated so as to protect the environment.

Company specifications for the selection and operation of all such equipment shall be reviewed and approved by the Agency in terms of environmental suitability, prior to commissioning of the pipeline.

All vehicles to be used by the Company shall meet or exceed the approved specifications with regard to requirements designed to achieve environmental protection.

All vehicles shall be operated within their operational specifications; operational restrictions designed to promote or achieve environmental protection shall be strictly followed.

DISCUSSION

The activities of inspection maintenance and repair of the pipeline and right-of-way are all heavily dependent on various items of transportation equipment. The line patrol is carried out mainly by light aircraft; access to the right-of-way is usually by helicopter or truck, travel along the right-of-way is by low-ground pressure vehicle or snowmobile; the movement of men and equipment from station to station by truck or aircraft and the annual resupply of stations and bases is by barge and truck. All these forms of transportation have a potential for causing or leading to environmental disturbance. In some cases careful operations or timing can limit or even eliminate the disturbance.

The proposals of the two Applicants with regard to aircraft and vehicles are generally similar. Foothills proposes to make more use of conventional highway trucks as the Mackenzie Highway is extended down the Mackenzie Valley and to be much more dependent on helicopters, including large heavy lift helicopters, for the movement of men and materials to compressor sites. Canadian Arctic Gas proposes to use more fixed wind aircraft of the "medium" size (e.g. D.H. Otter) and to make more use of various low ground pressure vehicles for travel along the right-of-way. Both Applicants refer to the possibility of using air cushion

vehicles for maintenance and repair work. Canadian Arctic Gas's plans in this regard are more developed.

Foothill's heavy reliance on helicopters for transport of equipment and men gives rise to concerns over the reliability of their plans. Helicopters cannot operate, legally and safely, under adverse weather conditions such as fog, icing, darkness, extreme low temperature and, in particular, white-outs. Should an emergency situation arise under any one of these conditions, Foothills response capabilities could be severely curtailed.

RECOMMENDATIONS

1. Preliminary plans for the operation of aircraft, off-road vehicles, boats and air cushion vehicles shall be submitted to the Agency at the time of final design. Detailed plans are to be developed by the Company in conjunction with the relevant government agencies, under chairmanship of the Pipeline Agency, prior to commissioning of the pipeline.

AIRCRAFT OPERATIONS

The main impact of normal aircraft operations is likely to be on animals and particularly aggregations of animals such as calving caribou, resting or staging birds or overwintering Dall sheep. Isolated animals such as nesting falcons are also highly vulnerable. Any animal is likely to be disturbed by low-flying aircraft, particularly if the aircraft follows them or "buzzes" them. Harassment of animals is illegal. The impact of normal operations can be largely avoided by not flying too low over animals that are sensitive to disturbance, either at all times or at such times when their sensitivity is high. Helicopters have a much greater impact than fixed wing aircraft on wildlife. Accordingly, greater restrictions have to be placed on their use.

RECOMMENDATIONS

2. All aircraft operations shall be in accordance with plans worked out in conjunction with and supervised by the relevant Territorial wildlife agency and the Canadian Wildlife Services, and designed to meet the concerns outlined in the sections of this report on "Wildlife Protection". Such plans shall specify types of aircraft, frequency of flights,

minimum flying height, flight corridors and areas of avoidance and provisions relating to landings by helicopters. In addition aircraft should be operated under the following constraints:

a) The Company shall not be permitted to rely exclusively on helicopters for emergency access to the right-of-way.

b) Supply aircraft flying between compressor stations and public airports shall maintain a minimum altitude of 2500 ft except as in clause (v), below.

c) No aircraft shall be operated in such a manner as to harass, chase or unduly disturb any animal.

d) Along the north slope of the Yukon, no aircraft shall fly at any altitude of less than 2500 ft within two miles of calving caribou of the post-calving aggregations of caribou.

e) Along the north slope of the Yukon and in the Mackenzie Delta, no aircraft shall fly at an altitude less than 5000 ft within two miles of concentration of staging geese.

f) Along the west side of the Mackenzie Delta and the eastern slopes of the Richardson Mountains, no aircraft shall fly at an altitude of less than 2500 ft within two miles of Dall sheep when lambing or overwintering, or within two miles of mineral licks used by Dall sheep.

g) Generally, no aircraft shall fly at an altitude of less than 2500 ft within two miles of any concentration of white whales.

h) Generally, no aircraft shall fly at an altitude of less than 2500 ft within two miles of the nest site of a peregrine falcon between April 15 and August 31 of any year.

i) Any similar restrictions imposed at any time by the relevant Territorial of Federal wildlife agencies.

j) No aircraft shall land in any of these restricted areas.

k) If helicopters are used as support vehicles for foot-patrols, all the above restrictions are to be observed.

l) In forested regions, line patrol aircraft are not to "herd" or chase animals along the right-of-way. The aircraft is to climb and circle, and allow the animal to leave the right-of-way before resuming the inspection flight.

m) Flights should not be permitted to begin if there is any reasonable probability of weather conditions forcing the pilot to break any of these restrictions.

n) In any emergency situation, as few as possible of these restrictions are to be broken. At the conclusion of the emergency situation, a detailed report of the aircraft operations, including all incidents of potential wildlife disturbance is to be submitted within 30 days to the Canadian Wildlife Service and the relevant territorial wildlife agency.

OFF-ROAD VEHICLES

This covers vehicles that have been referred to during the Inquiry mainly as low ground pressure vehicles. They comprise various wheeled or tracked vehicle, designed for use in muskeg, over rock, or rough ground and over snow covered terrain, and even include sleighs and motorized toboggans or snowmobiles.

A wide variety of such vehicles, suitable for summer and winter operations over a range or terrain types, are available for the Company to choose from. Over the last several years, considerable improvements have been made in these vehicles, particularly changes to minimize the effect of the vehicle on the ground surface. Today, an appropriate vehicle, carefully operated can travel almost anywhere without damaging more than a very small proportion of the ground surface and surface vegetation mat, even when quite heavily laden.

Off-road vehicles will be used primarily for the transportation of equipment and supplies along the pipeline right-of-way, They will be used for normal maintenance and repair work and for emergency repairs. They may also be used for inspection jobs.

The key points are that the vehicle should be appropriate to the terrain and the season, the loading should be done so that the weight is evenly distributed over the wheels or tracks, and the vehicle has to be operated carefully and within the design limitations regarding slopes, ground bearing strength and soil shear strength.

The main area of concern over the use of off-road vehicles is that the ground surface vegetation mat will be damaged or destoyed, leading to erosion of the ground surface, disruption of the surface and shallow subsurface drainage, disruption of the soil thermal regions and the deposition of sediment on land or its discharge into waterbodies. A second area of concern is that animals may be disturbed or harassed by the passage or noise of the vehicle. The third area of concern is the manner in which such vehicles will cross streams and rivers, particularly in a summertime emergency situation. Both Applicants refer to "air-transportable pontoon sets" for use in this situation. The reliability of such units, the effect their use may have on river or stream banks and what problems can occur in their use are not well known. Until their satisfactory use has been demonstrated, they should be confined to crossings of streams which are known not to contain sensitive populations downstream of the crossing site at the time of the crossing.

During the construction of the pipeline, there will be some difficult locations where the temporary haul road established along one side of the right-of-way will diverge from the right-of-way for short distances. In general, such divergences are in areas of steep slopes, and river or valley crossings, and they will be laid out for wheeled vehicles, such as crew buses and pipe trucks. Such divergences are known in the trade as "shoo-fly roads." Some of these roads may have a part to play during the operation and maintenance of the pipeline, for by keeping them in a serviceable condition, maintenance vehicles could use the shoo-fly roads to avoid unnecessarily travelling steep or difficult ground. If this is the case, the shoo-fly roads should be laid out and constructed with this in mind. On certain slopes, it may even be necessary to build a gravel road as a shoo-fly. The value of such lines of relatively easy access may be particularly important in the event of an emergency situation arising in the summer time. The upkeep and use of such trails is infinitely preferable to having off-road vehicles finding new ways around obstacles on an unplanned basis.

Apart from careful selection and operation of off-road vehicles, the best way to avoid environmental disturbance is "fore-thought". A thoughtfully planned activity is much less likely to run into problems than a hurriedly mounted, and possibly under-equipped activity. The operation of vehicles along the right-of-way without damaging the drainage and erosion control structures will be made much easier if those structures have been designed to allow the easy passage of vehicles.

RECOMMENDATIONS

3. Travel along the right-of-way shall be in accordance with plans developed in conjunction with and supervised by the relevant territorial and federal wildlife, fish and land use agencies, as appropriate. Such plans shall specify types of vehicles, frequency of passage and times and areas of avoidance. In addition off-road vehicles shall be operated under the following restrictions:

   a) During the operational phase of the pipeline, the pipeline company or contractor vehicles shall be confined to

      i) land under lease to the company
      ii) public roads, or
      iii) right-of-way activities covered by a land use permit

   b) Pipeline company or contractor vehicles on public roads shall be licensed, shall obey all traffic rules, including direction of travel, speed limits and load regulations, at all times.

   c) Vehicles travelling from one part of the system to another, (i.e. not doing work) shall be operated on prepared and approved road surfaces, whether permanent or temporary, gravel or snow and ice, whether on lands under lease, lands under a land use permit, or public roads.

d) Vehicular travel along the pipeline right-of-way for maintenance purposes shall be confined, as far as possible, to the winter months when there is sufficient frost penetration and snow cover to provide adequate protection of the ground surface. This also applies to shoofly roads.

e) Vehicular traffic on the right-of-way shall be kept to a minimum, and preference shall be given to off-road vehicles at all times of the year. Tracked vehicles should be fitted with non-aggressive grousers on the tracks. Vehicles are to be operated at low speeds, and particular care is to be taken when turning vehicles so that the vegetation mat is not cut or scarred.

f) Under emergency conditions, summer travel along the right-of-way may be permitted. Summer emergency conditions comprise the following situations:

i) pipeline rupture resulting in interruption of service,
ii) an impending rupture demanding prompt corrective action,
iii) danger to human life, or
iv) a critical environmental hazard.

g) Land-use permits shall be obtained, in advance, for each and every operation which <u>may</u> involve the operation of pipeline company vehicles off-road and outside the lands leased by the Company.

h) All off-road vehicles shall be fitted with effective mufflers and control devices. These devices are to be kept in good working order at all times.

4. During the construction of the pipeline, the Company shall construct all drainage and erosion control devices of materials and in a manner that will allow easy passage of off-road vehicles without damage to the structure concerned.

5. The Company shall design, build and maintain selected shoofly roads in such a manner as to facilitate their long term use by pipeline maintenance and repair vehicles.

ROAD VEHICLES

A number of road vehicles, such as cars and light trucks, and work equipment, such as graders and loaders, will be required at each compressor station sites and at the headquarters site for local transportation and maintenance purposes. Such vehicles should be operated entirely on prepared gravel surface, such as the compressor station pad, airfield, wharf, stockpile site and connecting roadways, and on public roads. In this case, no major concerns arise.

Conventional highway trucks and tankers will be used for the resupply of sites and compressor stations accessible from the all-weather public road network. No unusual concerns have been identified.

RECOMMENDATIONS

6. Road vehicles and work equipment shall not be operated off prepared surfaces.

7. All road vehicles and work equipment shall be fitted with effective mufflers and emission control devices. These devices are to be kept in good working order at all times.

BARGES AND BOATS

Barges will be used to resupply sites and stations remote from the public road network. No unusual concerns have been identified, with regard to barge operations for resupply purposes. To the extent that the Company can influence the barge operators, the same restrictions recommended for the construction of the pipeline should apply. With regard to procedures, and particularly fuel handling, at Company owned wharves, the recommendations for the construction period must be followed.

Small boats will probably be used mainly for inspection work such as channel soundings at major designated river crossings and for inspection work along any pipeline within the Mackenzie Delta.

The main concern with such operations is the potential for disturbance of white whales in Shallow Bay, particularly during the calving period. Other than this, the occasional operation of small boats will not be very noticeable amongst the other boat traffic on the rivers concerned.

RECOMMENDATIONS

8. The use of boats by the Company shall be in accordance with plans worked out in conjunction with and supervised by the relevant Territorial and Federal wildlife, fish and land use agencies, as appropriate. Such plans shall specify the types and sizes of boats and motors to be used, the frequency and speed of passage, travel corridors and times and areas of avoidance.

9. The Company shall follow the procedures recommended for use during the construction phase of the pipeline when loading or unloading barges or transferring fuels to or from any barges.

10. Small boats with motors should not be used by the Company in Shallow Bay during the white whale calving period, from approximately July 1 to July 31 of any year.

SPECIAL WORK EQUIPMENT

Several items of special work equipment are required for the repair and maintenance of the pipeline and the right-of-way. In maintaining and repairing pipelines in southern Canada, the sort of equipment involved includes backhoes, bulldozers, side-booms, graders, loaders, and various wheeled trucks. All these vehicles have high to very high ground pressure and most have aggressive grousers or tread on the tracks or tires.

The widespread use of such conventional equipment would not be acceptable in the maintenance and repair of this pipeline, because of the severe damage that would be done to the ground surface and surface vegetation mat. Neither Applicant contemplates the use of such equipment except at a work site. In summer the equipment will be transported to the work sites on low ground pressure vehicles, and even then various forms of protective matting will be used in an attempt to minimize terrain damage. In winter, once the ground is frozen and there is a sufficient cover of snow, the work equipment can be safely driven along the right-of-way under its own power. In many instances, it will be appropriate to construct a snow road for such movements, particularly if road vehicles are needed. For summertime emergency situations, both Applicants plan to have some low ground pressure vehicles equipped as work vehicles, backhoes, side-booms or gravel trucks. The operating

restrictions recommended for off-road vehicles will also apply to these special pieces of equipment.

Both Applicants have also indicated that air cushion vehicles (also known as "Hovercraft", ground effect vehicles and surface effect vehicles) will be employed where feasible. Foothills recognize that the effectiveness of air cushion vehicles is limited by surface configurations and topography. Canadian Arctic Gas stated, both in the Application and in evidence, that they intend to have an air cushion vehicle based at Inuvik to transport equipment and materials across waterbodies during flooding and ice flow conditions, especially in an emergency situation. Cross-examination of Arctic Gas witnesses showed that they were not familiar with the designs or operational capabilities and limitations of the currently available machines, the type of machine they would choose, the manner of testing and use of such machine or the potential for environmental impact. Three main areas of concern have been identified regarding the use of air cushion vehicles: noise, terrain damage and reliability.

Noise

Towed machines are reported to be no worse than any large diesel engined vehicle. However, the noise of the tractor unit, which is usually a diesel engined vehicle, must be added to that of the air cushion-raft. Noise measurements on two towed air cushion rafts gave levels of about 80 dBA at 100 feet from the stationary machine in hover mode, which is equivalent to 60 dBA at 1000 feet. Self propelled machines can be much noisier, due to the propulsion equipment. However, good data on environmental noise is not readily available particularly for a cruising machine. The only figure available is one of 92 dBA at 500 feet; this is equivalent to 106 dBA at 100 feet, and 86 dBA at 1,000 feet.

The impact of the operation of either vehicle on wildlife is likely to be extreme. All animals within a certain distance, which is not presently known, will be affected. Those that can, will flee, and in the case of nesting birds, this will result in decreased reproductive success due to chilling or predation of eggs or chicks. A maximum noise level of 50 dBA at 1,000 feet has been recommended as desirable for compressor stations. If this can be interpreted to mean that a noise of 50 dBA will not unduly disturb wildlife, the following conclusion can be drawn:

a) One pass of a towed air cushion vehicle will lead to more or less severe disturbance (noise greater than 56 dBa over a swath of 3200 feet wide, with lesser disturbance, (noise levels 50-56 dBa) for a further 1,600 feet on either side, for a total width of 6,400 feet.

b) Similarly, one pass of self propelled air cushion vehicle will lead to severe disturbance over a swath of 6,400 feet wide and some disturbance over a swath of 12,800 feet wide (2 1/2 miles).

c) In addition, noise and air blast can be expected to severly disturb white whales, for an unknown distance from the machine.

Terrain Damage

Two aspects of terrain damage appear important. These are first the impact of the air cushion itself and second, in the case of towed or tow assisted air cushion vehicles the impact of the towing vehicle or tractor.

Contact between the air cushion skirt and the ground causes some damage to vegetation and a slight increase in the depth of thaw of the soil. The effects are most serious in wet areas and on the raised tops of soil hummocks. The recovery period can be as much as five years, following several passes of the machine. Patterned ground can make air cushion vehicle operations difficult as the troughs between polygons or earth hummocks can cause excessive air cushion loss, immobilization and skirt damage. No impacts appear to result from winter travel over a frozen and snow-covered surface.

The impact of a tractor unit towing an air cushion vehicle is dependent on a number of factors. These include the mass of the air cushion vehicle, the slope angle and length, the nature of the tractor unit and the manner of use. On steep slopes, there is a tendency for the air cushion to leak out of the downslope side of the air cushion vehicle skirt, thus the uphill side comes in contact with the ground, resulting in mechanical damage to the terrain. A large heavily laden air cushion vehicle will require a high draw-bar pull to move it up a steep slope. If this is high enough to result in slippage of the wheels or tracks of the tractor, considerable terrain damage can result. This damage can

be largely avoided by having the tractor unit winch the air cushion vehicle up slopes, rather than tow it up.

One complication to the operation of an air cushion vehicle overland is that it cannot operate on a side-slope. The vehicle just slides down to the bottom of the slope. Thus a towed air cushion vehicle would need two tractor units, one in front and one behind to enable it to follow the right-of-way.

Reliability

The purpose of having an air cushion vehicle stationed at Inuvik is to provide unrestricted access to the pipeline right-of-way for heavy equipment and material, at all times of the year and with a minimum of damage to the terrain. Undoubtedly such a vehicle will permit operation over water, ice, ice-infested water (during freeze-up and break up) and over land.

However, there are several factors which will limit the usefulness of the machine in parts of the regions. These include its poor slope climbing capability, its inability to operate in moderate to severe weather conditions, particularly in high winds, poor visibility, dangerous icing conditions or over high waves, and its poor obstacle crossing capability. Another aspect of reliability is the great difficulty in making field repairs, particularly to the skirt. Skirt wear and failure can be very rapid over rough ground. Most machines lack a self-jacking capability, but if other machines are used to assist in skirt repair, considerable terrain damage can result.

Conclusion

Air cushion vehicles are unacceptably noisy for regular use in a wilderness area; if operated other than with great care and skill, they have a potential for causing terrain damage; and their limited ability to cope with sloping terrain and obstacles limits the areas in which they can be used effectively. Problems of navigation, safety and reliability of the machine per se, repair difficulty, etc., have not been discussed. Some of these also have implications for environmental disturbance and damage.

RECOMMENDATIONS

11. Low ground pressure vehicles fitted as work equipment shall observe all the operating restrictions recommended for off-road vehicles in general. (Recommendations 3, 4 and 5 4 above.)

12. The Company shall not rely exclusively on any form of air cushion vehicle for the maintenance and repair of the pipeline or the right-of-way. If the Company wishes to have such a machine on strength in Inuvik during pipeline operations to aid the other equipment, detailed procedures to avoid or mitigate all aspects of environmental damage shall be developed; and submitted to the Agency for approval before commissioning of the pipeline and any use is made of the machine.

13. Operation of air cushion vehicles shall be in accordance with plans developed in conjunction with and supervised by the relevant Federal and Territorial wildlife, fish and land-use agencies. Such plans shall specify the type and size of equipment, frequency of passage, travel corridors, and times and areas of avoidance.

14. Air cushion vehicles shall not be operated along the Yukon north slope or in the Mackenzie delta in summer.

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FACILITIES -- INSPECTION, REPAIR AND MAINTENANCE

GENERAL RECOMMENDATION

In the operation and maintenance of all its facilities, including but not limited to compressor stations, meter stations, valves, airfields, wharves, maintenance depots and the like, the Company shall have the continued protection of the people and environment of the Mackenzie Valley and northern Yukon as a primary objective.

DISCUSSION

There will continue to be a considerable amount of human and industrial activity at the complexes of facilities associated with each compressor station site when the construction phase ends and operation of the pipeline begins. There will be lesser amounts of activity at the smaller sites, such as meter stations, valves, river crossings and remote communications sites, and there will be greater amounts of activity in the settlements where the Company's division and district headquarters will be situated.

The compressor station sites will have been used for construction camps and material stockpiles, and so the general level of activity will actually decrease after commissioning of the pipeline. There will, however, be periods of more intense activity if the Company loops the pipeline or adds further compression.

A wide range of activities will occur at the various sites, but most will fall under the five general headings of inspection, maintenance, repair, resupply and waste disposal. Along with the engineering activities, such as compressor and chiller maintenance, there will be a range of supporting activities, such as storage of supplies and emergency equipment, water supply and sewerage for living quarters and vehicle repair; and above all there will be the continual presence of people in an otherwise sub-wilderness area.

All these activities are essential to the continued safe operation of the pipeline, and so their overall impacts cannot be avoided. The objective of the terms and conditions must therefore be to reduce the effects to an acceptable level. There are no serious concerns over most of the activities which will take place inside the compressor stations. The serious concerns

relate to matters which will or may directly affect the environment. Some of these activities include:

storage of fuels and toxic materials
waste disposal -- sewage, garbage, trash, lubricants,
water supply and treatment,
noise from compressors, chillers and blowdowns,
exhaust emissions from compressors, flares and incinerators,
use and maintenance of wharves and airfields,
emergency repairs to the pipeline or right-of-way,
repairs to civil works at the complexes.

The other main area of concern relates to the presence of people, and their impact on the fish and game populations of the area.

The proposals of the two Applicants, in regard to station, and facilities operation, appear to be quite similar and are satisfactory in so far as they go. More detailed plans and procedures will have to be developed and submitted to the Agency at the time of final design. The following recommendations are to provide guidance to the Company in preparing the operating plans, and to the Agency in reviewing those plans. The recommendations will indicate some examples of matters of concern to the Inquiry; the listing of topics is not complete and is not intended for use as a formal checklist.

RECOMMENDATIONS

1. The Company shall prepare detailed plans and procedures for the operation, inspection, maintenance, repair, resupply and waste disposal of all facilities associated with the pipeline, and shall submit them to the Agency for approval at the time of final design.

2. The plans shall cover, but not be limited to, the following types of facilities:

compressor stations (initial and future)	airfields
meter stations	roads
valves	wharves
river crossings (work pads)	stockpiles
borrow sites	communications sites
divisional headquarters	maintenance depots
	district headquarters

Individual plans shall be developed for each of these, as necessary.

3. In the operation and maintenance of the various facilities, the following criteria should be observed.

   a) The storage and handling of fuels and toxic materials, the supply of water and all aspects of waste disposal shall comply with the recommendations of the section on "Construction Services and Activities".

   b) Waste disposal and emissions (including noise) from facilities shall comply with the requirements of the section on "Physical Environment".

   c) The stability of slopes, the efficacy of drainage and erosion control structures and the integrity of new vegetation at and around all facility sites shall be maintained. Tree and shrub control shall be achieved by mechanical means only; no herbicides shall be used.

   d) The use of vehicles, aircraft, boats and work equipment shall comply with the recommendations in "Transportation Requirements for Operation and Maintenance".

   e) There shall be no hunting of game from facility sites, other than the district or divisional headquarters at which each person is domiciled, or using any Company property.

   f) Sport fishing from facility sites shall comply with the requirements in "Fisheries and Fishing".

SOURCES OF INFORMATION

1. <u>Transcripts, Exhibits, Basic Document</u>

CAGPL	Carlson, M., Fielder, D.E., Hurd, L.G. (40-42:5180-528)
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CAGPL	Application; Section 13.6
FH	Application; Section 3F
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2. Reports

Stanley Associates Engineering Ltd.,
1976 Draft environmental code for the development of the proposed Mackenzie Valley gas pipeline (for Environmental Protection Service, DOE)

DEACTIVATION, CLOSURE AND ABANDONMENT

GENERAL RECOMMENDATIONS

Upon abandonment of the pipeline, or any part thereof, the Company shall remove all above ground structures not required by other parties on the same site and stabilize and vegetate all exposed surfaces other than pads, berms and embankments and generally clean-up the right-of-way and all lands used by the Company.

Further, the Company shall make financial and organizational provision to do this work, and to continue an appropriate level of monitoring and maintenance of the lands to ensure their continued stability until such time as the government should agree that the Company has discharged its responsibilities.

Should the pipeline be deactivated or closed at any time, the Company shall make financial and organizational provision for continuing control of all lands, facilities and equipment. Special attention shall be paid to terrain stability, protection of aquatic environments and control or removal of all potentially polluting materials used in the operation or maintenance of the pipeline.

DISCUSSION

One of the more unfortunate consequences of industrial developments has been the derelict lands remaining after cessation of activity. Until recently, the costs of living with or reclaiming such areas of dereliction have generally been borne by society at large. Recently such costs have come to be regarded as being the responsibility of the Company or individual who originally profited from the industrial activity concerned. This process is one of "internalizing externalities", in economic terms (Mead, 1976).

For a project of the size of the Mackenzie Valley gas pipeline, running through areas of more or less unspoiled wilderness for much of its length, it is clear that upon its termination every effort must be made to return the land to something approaching its original state, and to ensure that the continuing impacts of the construction and operation be minimized to the greatest extent possible. In the Report of the Pipeline Application Assessment Group, the following question is posed:

"... does the evidence provided suggest [the pipeline] can be made to operate without, at the same time, building up insoluble or intractable problems for that distant future date when it becomes inactive or disused?" (p. 281).

No clear answer to this question is presently available. The Assessment Group pointed out that, given the new technology of a chilled, large diameter gas pipeline buried in permafrost soils, and generating its own "artificial permafrost" in the frost bulb, it is difficult to assess the potential impacts of abandonment of the system without having detailed "geothermal and other data ... available at the outset on the effects of chilling and its cessation upon representative terrain types" (p. 281).

Arctic Gas, in its original Application, recognized that there would be some concern over the matter of abandonment of the pipeline. At that time, it proposed that the pipe in the ground would be left in place and surface facilities would be either removed and salvaged, turned over to other users (including the communities) or the sites restored and returned to nature. They claimed that vegetation growth on the right-of-way would eventually remove all visual evidence of ths system and that the pipeline itself would remain frozen in the permafrost soil.

In its Responses to the Assessment Group, Question 56, Arctic Gas considered the thawing of the frost bulb, developed due to chilling, in areas of previously unfrozen ground and concluded that because of the very slow rate of such thawing, erosion and slope instability problems would be very few. Witnesses for Arctic Gas reaffirmed this view, and the conclusion was that impacts of abandonment would be insignificant (Hemstock, 81:12006-10).

Other points made by the witnesses were:

a) No consideration was being given to proposals to patrol and maintain the right-of-way after abandonment (Hurd, 42:5494-95).

b) No studies had been done or were underway to assess the impacts of abandonment (Hemstock, 81:12006-10).

c) No estimate has been made of the cost of terrain rehabilitation and other works which may need to be done after abandonment. This was not considered as a cost of the project (Hemstock, 81:12006-10).

d) In areas where the buoyant effect of the empty pipeline could present a problem, the pipe could be filled with water to prevent it floating (Hemstock, 82:12285).

e) Following abandonment, the Company will cease its monitoring and maintenance efforts (Hemstock, 82:12885).

f) If the frost bulb were to thaw rapidly, there could be some slope stability problems and some erosion along the right-of-way, particularly along the line of the trench (Harlan, 82:12291-92).

Witnesses for Foothills indicated that its proposals were essentially similar to those of Arctic Gas (Hushion, 68:10096; Mirosh, C-31:3014).

Throughout the discussion on the matter of abandonment by witnesses for the Applicants no mention was made of the problems of abandonment of the surcharge berm.

McTaggart-Cowan and Templeton (EPB) proposed that the costs associated with abandonment should be paid for by the project and that, when the end of the project life was in sight, the Company should be required to put some of its reserve funds into a special fund to pay for the clean-up and abandonment. In the event of problems arising after abandonment, their proposals were to the effect that society would have to devise new protective mechanisms. The opinion was expressed that regulation of all this would be the responsibility of the National Energy Board (108:16449-53; 11653-55).

Other pertinent evidence was given by witnesses for the Environment Protection Board and the Canadian Arctic Resources Committee. Weedon (CARC) suggested that consideration of the consequences of activities along the right-of-way, including removal of the pipeline when no longer needed, should be among the criteria applied in the selection of alternate routes (54:7457-58). This suggestion should be expanded so that all the implications of abandonment are considered as part of the route selection process.

For the purposes of these recommendations, the following definitions are used : deactivation, a temporary shut-down of the pipeline system or any part of it for a period not exceeding twelve months; closure, deactivation for a period of more than twelve months or an apparently permanent shut-down of the pipeline system or any part of it, but with continued control over lands, facilities and equipment by the pipeline company; and abandonment, permanent closure with removal or disposal of above-ground structures and equipment stabilization and restoration of all lands and with no continuing control by the company.

The distinction between deactivation and closure is made because any gas pipeline that is not used for a period of twelve months or more may not be put back into use without the specific approval of the National Energy Board and without being retested, including a hydrostatic pressure test (Gas Pipeline Regulations, subsection 84(3), 1974).

RECOMMENDATIONS

1. Upon abandonment of the pipeline system, or any part of it, the Company shall:

    a) remove all toxic or polluting materials;

    b) remove all above ground structures not required by other parties on the same site, including but not limited to compressor stations, camps, fences, towers, lights, valves, tanks and above ground piping;

    c) level all berms around fuel storage areas and sewage lagoons;

    d) fill-in and restore all sewage lagoons (see "Wastewater and Sewage: Camps and Facilities");

    e) where necessary, regrade the surfaces of all pads and embankments, to provide for adequate surface drainage;

    f) stablilize and revegetate those pads and embankments not required for immediate use by other parties, individuals or communities; and

    g) generally clean-up, stabilize and restore the right-of-way, shoofly roads, and all lands used at any time by

the Company. Reclamation and restoration standards shall comply with all those recommended for the abandonment of facilities used during the construction of the pipeline.

2. In sections of the system where a surcharge berm has been built to control frost heave, the Company shall remove any and all culverts which may have been installed in the berm, and shall provide a stable, unobstructed drainageway of adequate capacity for a 1-in-50 year flood.

3. The Company shall remove any and all culverts or bridges in permanent project roads which are not to be taken over immediately by any other party or individual; and in such cases shall provide a stable, unobstructed drainageway of adequate capacity for a 1-in-50 year flood (see also "Roads, Airstrips and Helipads").

4. The Company shall stabilize, grade and restore all borrow areas and waste disposal sites used during the operation and maintenance of the pipeline system and associated facilities, and not previously restored.

5. Where excavation of a known archaeological site has not been possible due to the Company's occupation or use of any lands, upon closure or abandonment of the system at the localities concerned the Company shall make financial and other provisions for the excavation of each site, in accordance with the archaeological plans of the project at the time of construction.

6. The Company shall present a preliminary plan and environmental impact statement covering the matters of deactivation, closure and abandonment of the pipeline system as part of the final design. This plan shall include, but not be limited to:

   a) Provision of an organizational structure and staff to carry out the necessary works associated with abandonment of the pipeline system, and to provide necessary monitoring and maintenance works following completion of such works until such time as the Government shall agree that the Company has discharged its responsibilities.

b) Arrangement for sufficient funds to adequately support the works and staff described above.

c) A description of the probable environmental impact of abandonment of the system. Particular emphasis should be placed on the manner and rate of dissipation of any frost heave developed over the pipeline and of the frost bulb developed in previously unfrozen ground.

d) Details of research proposed to be undertaken prior to abandonment to determine more exactly the probable environmental impacts and the rates of dissipation of frost heave and the frost bulb.

The plan should clearly demonstrate that any problems foreseen as a result of abandonment have been considered in the selection of the pipeline route and the location of the associated facilities.

7. Should the pipeline be closed at any time, the Company shall make financial and organizational provision for the continuing control of the system and all lands, facilities and equipment. Special attention shall be paid to terrain stability, the protection of aquatic environments and the control or removal of all potentially polluting materials used in the operation or maintenance of the pipeline.

8. Should the pipeline be deactivated at any time, the Company shall continue all inspection, maintenance and repair activities at normal strength. Special attention shall be paid to terrain stability, protection of aquatic environments and the control of all potentially polluting materials used in the operations and maintenance of the pipeline.

9. The Company shall present preliminary plans and environmental impact statements covering closure and deactivation of all or part of the pipeline system for various time periods as part of the final design. Appropriate time periods would be one week's and one month's shut-down in each season: winter, spring (run-off), summer and autumn and a one year shut-down. The plans and environmental impact statement should also cover the time of start-up following such deactivation or closure and a short period of time thereafter.

10. In the event of a closure of the pipeline, the reactivation plans shall contain plans for retesting the pipeline,

including hydrostatic pressure testing. These testing plans shall comply with all relevant recommendations in this submission, including but not limited to those dealing with "Pipe Testing", "Water Supply and Intakes", "Solid and Liquid Wastes: Construction/Industrial Activities" and "Spill Prevention and Control".

SOURCES OF INFORMATION

1. Transcript, Exhibits, Basic Documents

CAGPI Application; Section 14.d.N.6.5.
Responses; Question 56. PAAG Section 8.18

2. Reports

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1976 "Social benefit cost analysis of offshore drilling" in The question of offshore oil; Mitchell, E.J. (ed.); American Enterprise Institute for Public Policy Research, pp. 69-76.

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1974 Gas pipeline regulations.

REGULATION

GENERAL RECOMMENDATIONS

The Company shall plan, organize and control the operation, maintenance and abandonment of the pipeline in a manner that will minimize its impact on the physical and biological environment and on the people and their traditional activities in the Mackenzie Valley and northern Yukon.

The government should conduct a detailed review of all existing laws, regulations and practices to determine their applicability to and efficiency for the problem of regulating the operation, maintenance and abandonment of the pipeline.

The government should make careful organizational provision for the transfer of control from the Agency to permanent departments and agencies.

The Agency should conduct a detailed review of all aspects of its tasks, operations and procedures, and its successes and failures, prior to its disestablishment.

DISCUSSION

This topic is divided into three sub-topics for the purposes of the discussion. These are:

a) Company procedures and control
b) Government monitoring and inspection, and
c) The period of transition from the Agency to the government at large.

Company Procedures and Control

Most aspects of the Company's internal control, planning and operating procedures will have no particular effects on the physical or biological environment of the pipeline corridor. The various items that are of concern are discussed briefly.

The other sections under "Project Operation" all require a considerable amount of planning be done for the operational phase of the project. Most of this planning has to be completed, at least in outline, by the time of final design. It is expected

that the staff and organization who will carry out these plans and operate the pipeline will be closely involved in producing the plans. An "environmental awareness" on the part of these people will go a long way towards avoiding many of the potential problems of pipeline operation and its impact on the environment. During the formal hearings, many references were made by witnesses for both Applicants to the proposed existence of a number of different manuals to guide the project staff in the various tasks involved in the design and construction of the pipeline. Reference was also made to a similar manual or manuals to be produced for the operational phase of the pipeline (41:5332). These documents and the data files that back them up, are important components of the operating plans, and are a key item in the success of measures to mitigate undesirable environmental effects. Consequently, the environmental advisors of the operating staff of the project must be involved in the production of these manuals.

As well, access to the environmental advisors must be readily available for the operating staff at all times throughout the operational phase of the pipeline. Ready access to environmental advice and information will be particularly important during any emergency situations, such as pipeline ruptures, washouts or fires, that may arise. Another important task of the environmental staff will be the environmental education of all the other staff. Some of the operating staff may have received the environmental briefings that will be given to the construction forces. However, a more intensive and differently oriented program will be required for the operating staff. This program should include geotechnical information as well as biological and sociological information, and could be integrated with safety training and other orientation programs. Periodic refresher sessions should be made available.

In other places in this submission, the Company is being asked to undertake a considerable amount of monitoring and repeated observation of various attributes of the environment. This will be integrated with the more conventional inspection and line patrol activities, and will be carried on throughout the operating life of the pipeline, up to final abandonment of the project. There are two purposes to this surveillance and monitoring. One is the assessment of the actual environmental impact of the project, as opposed to the predictable impact. The other is continued vigilance for aberrant conditions that pose some threat to the stability of the pipeline, the right-of-way or

the local environment. For any surveillance system to be effective, it must include a "reaction component" so that, when a critical situation arises, the Company recognizes it and responds appropriately. Essentially, the Company is being asked to maintain a permanent "state of readiness".

The environmental impact assessment role of the monitoring program will require the keeping of detailed records of all the observations made. These records should not be integrated with the conventional engineering records to the extent that they cannot be retrieved separately if needed. Like the engineering records, however, they should be retained for at least the lifetime of the project. The Company is also being asked to file reports of its various inspection, maintenance and repair activities, over and above those required by the Gas Pipeline Regulations (NEB, 1974). One important aspect of inspection, monitoring, record keeping and reporting is that all the information so gathered should be used. It should be used by the Company in improving its operating procedures, so if, for example, a particular slope exhibits repeated failures of erosion control devices, the Company should redesign and reconstruct the devices rather than go on repairing them to the old design. The lessons learned in this way will be particularly valuable if the Company extends or loops any part of the system.

Government Monitoring and Inspection

It is assumed that for most of the operating phase of the pipeline, day to day regulation of the Company will be done by the permanent government departments and agencies having relevant responsibilities. It is questionable whether the present framework of laws, regulations and practices will provide the government with the tools to adequately control and monitor the operation and maintenance of this project throughout its expected life of 30 to 60 years or more and finally its closure and abandonment. A review of existing federal and territorial law is needed, so that gaps or defficiencies may be identified and steps taken to correct them. This should be completed, including the corrective measure, before the Agency ceases to exist and so ceases to control the project.

As part of this review, the government should realize that the high standards of environmental protection which will be required during the construction of the project must not be allowed to lapse. Continued, rigorous enforcement will be required. This,

plus the very size of the project area will certainly lead to a need for increased enforcement staff in a number of government departments and agencies, at the very least.

The government will have a continuing responsibility to monitor the effects of the pipeline on the environment and the people of the Mackenzie Valley and northern Yukon. This will require a degree of direct inspection of the right-of-way and facilities by government officers. It will also involve the review of any changes in the operating plans and manuals that the Company may propose, or the initiation of any changes which the government may feel are necessary.

Transition Period

In the section of this submission on "Project Regulation:The Government" the creation of a single Agency to control all the technical, environmental and social aspects of the project is proposed. This Agency is expected to exist only for the period of pipeline design and construction, and to phase out of existence some short time after commissioning of the pipeline and its associated facilities.

There may be a partial exception to this phase-out, in that the creation of a monitoring program is also proposed which would continue to function until the pipeline system is closed down and abandoned. If this monitoring program is created under the aegis of the Agency, then only the parts of the Agency concerned with construction coordination would cease to exist.

In either case, after completion of the pipeline and before any part of the Agency ceases to exist, it should conduct a major internal review of its operations and its relationship with the Company, the government and the people of the North. At the conclusion of this review, the Agency should compile and publish a "disestablishment report" which will outline the tasks that the Agency was charged with, the manner in which it approached them, and the successes and failures that occurred and make recommendations to government that will be of value and assistance in the regulation of future large construction projects. The comments of the Company on the role and efficiency of the Agency should also be compiled as part of this review process.

At the time of its disestablishment, the regulatory and enforcement responsibilities of the Agency are expected to be returned to the permanent departments and agencies of government. A smooth transition will require careful planning by the Agency and by the other branches of government concerned. As part of this transition, it will be necessary for a decision to be made on the disposition of the Agency's files and records. Some will have to be passed to the successor agencies, other should perhaps be kept together.

RECOMMENDATIONS

1. The Company shall present comprehensive preliminary plans for all aspects of operations, maintenance and abandonment of the pipeline and all associated facilities at the time of final design. Preliminary drafts of all operations and maintenance manuals shall be produced at this time also. The plans and manuals shall be submitted to the Agency for approval.

2. Final operations and maintenance plans and manuals shall be developed and submitted sufficiently far in advance of commissioning of the pipeline to allow a thorough review by the Agency. The actual timing of this submission shall be determined by the Agency.

3. The operations and maintenance plans and manuals are to be supported by adequate geotechnical, biological and sociological and engineering information. The environmental and sociological staff of the Company are to be involved, from the beginning, in the production of all plans and manuals, as well as in the compilation of supporting data.

4. All levels of operations staff are to have ready access to competent environmental advice throughout the life of the project. In particular, the Company shall ensure that environmental advisors are "on-call" at all times in event of any emergency incidents.

5. The Company shall provide all employees, at all levels, with an environmental, social and safety training program. The details of this program are to be submitted to the Agency for approval. It is expected that the program will draw on the experience gained in environmental briefings of construction forces.

6. The Company shall carry out all inspection and monitoring activities required elsewhere in this report or requested by the Agency, in a conscientious manner. All monitoring and inspection programs shall include details of critical levels and the appropriate actions to be taken if a critical level is approached or exceeded.

7. The Company shall keep records of all inspection, monitoring, maintenance and repair activities, and shall file reports, as detailed elsewhere in this submission.

8. The Government should continue to require high standards of environmental protection throughout the operation of the pipeline and in its abandonment.

9. In its detailed review of existing laws, regulations and practices, the Government should identify any deficiences in regard to protection of the environment and peoples in the project area and take steps to correct them before the Agency ceases to exist.

10. The Company should be requested to produce reports on the role and efficiency of the Agency as part of the Agency's disestablishment report.

SOURCES OF INFORMATION

1. Transcripts, Exhibits, Basic Documents

CAGPL	Carlson, M.E., Fielder, D.E., Hurd, L.G. (40-42:5180-528)
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